PROTECTION SPRAYING AGAINST SPRUCE BUDWORM IN NEW BRUNSWICK 1984

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PROTECTION SPRAYING AGAINST SPRUCE BUDWORM

IN NEW BRUNSWICK

1984

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SUMMARY

In 1984, Forest Protection Limited applied insecticides aerially to 1.03 million ha of spruce budworm (Choristoneura fumiferana (Clem.)) infested forest land in New Brunswick. Approximately 85 percent of the area received a double application of either fenitrothion (Sumithion) or aminocarb (Matacil 180F) insecticide in water-based formulations. Another 11.5 percent of the area received a single application of aminocarb, and the balance (about 3.5 percent) received a single application of undiluted bacterial insecticide Bacillus thuringiensis, (B.t.) (Thuricide 48LV). Spray aircraft included TBMs, single-engine agricultural spray planes and helicopters. Objectives of the program were to limit budworm defoliation and retain at least 60 percent of the current year's foliage on balsam fir (Abies balsamea (L.) Mill.) and 50 percent of the current year's foliage on red-black spruce(Picea rubens Sarg. - P. mariana (Mill.) B.S.P.).

Analysis of defoliation data revealed that the program was very successful in meeting foliage protection objectives on all host species. Success, however, was tempered by observations that defoliation in a high proportion of untreated areas also met the program objectives. Spray-induced effects were enhanced by cool spring temperatures and wet weather during the late larval stage which were conducive to good tree shoot growth yet unfavourable for budworm feeding.

Compared to 1983, there was a higher probability of naturally retaining specified levels of foliage across the range of larval densities encountered. Nevertheless, spraying increased the probabilities of attaining or exceeding the specified objectives of foliage retention.

No clear and consistent differences between treatments could be determined because of the variable number of observations between treatments at each larval density. Defoliation was generally lower in treated plots than untreated plots though differences were not statistically significant. Budworm survival to the pupal stage in unsprayed areas varied with early larval densities and ranged from 8 to 44 percent on balsam fir and from 5 to 25 percent on red-black spruce. Reductions in survival in treated areas were not presented, since they were not used as a measure of the efficacy of the program.

Combined aerial and ground surveys following the spray program revealed about 0.73 million ha of moderate to severe defoliation in the larger more well-defined areas of damage. Widely scattered point observations of defoliation from a ground survey revealed more extensive damage but calculation of the area defoliated was not practical.

The egg mass survey revealed that about 3.57 million ha were expected to be moderately to severely infested in 1985. Hazard values at the sample locations indicated an over-all improvement of tree condition as there was a 17 percent reduction in the proportion of plots in the moderate and higher categories compared to 1983. This improvement was attributed to a combination of treatment and natural factors in sprayed areas and to natural factors in unsprayed areas including good shoot growth and less intensive feeding by larvae in 1984.

RÉSUMÉ

Au Nouveau-Brunswick, en 1984, des avions de la société Forest Protection Limited ont épandu des insecticides sur une étendue forestière de 1,03 million d'hectares qui était infestée par la tordeuse du bourgeon de l'épinette (Choristoneura fumiferana (Clem,)). Près de 85% des zones traitées ont reçu deux applications d'insecticide en solution aqueuse, soit du fénitrothion (Sumithion) ou de l'aminocarbe (Matacil 180F). En outre, 11,5% ont reçu une seule application de l'insecticide microbien non dilué Bacillus thuringiensis (B.t) (Thuricide 48LV). Les appareils utilisés pour l'arrosage comprenaient des TMB, des monomoteurs et des hélicoptères servant à l'arrosage agricole. Le programme avait pour objectif de limiter la dénudation des arbres attribuable à la tordeuse du bourgeon de l'épinette et de conserver au moins 60% du feuillage de l'année pour le sapin baumier (Abies balsamea (L.) Mill.) et 50% du feuillage de l'année pour l'épinette noire/rouge (Picea rubens Sarg. - P. mariana (Mill.) B.S.P.).

L'analyse des données sur la défeuillaison des essences attaquées par la tordeuse du bourgeon de l'épinette a révélé que, dans tous les cas, le programme de protection du feuillage a été une belle réussite, en ce sens que les objectifs prévus ont été atteints. Cependant, ce succès est moindre qu'il n'y paraît à première vue, si l'on se fie aux observations faites dans les zones non traitées car, en règle générale, la défeuillaison de ces zones a aussi atteint les objectifs du programme. Les températures fraîches du printemps et les pluies qui sont tombées pendant les derniers stades du développement larvaire ont probablement intensifié les bienfaits du programme d'arrosage, en favorisant le développement des nouvelles pousses tout en nuisant au cycle d'alimentation des larves.

Par rapport à 1983, on pouvait davantage s'attendre à conserver naturellement un pourcentage précis de feuillage, eu égard aux densités larvaires présentés. Néanmoins, l'arrosage a augmenté la possibilité d'atteindre ou même de dépasser les objectifs prévus en matière de protection du feuillage.

Il a été impossible d'établir des différences précises et uniformes entre les traitements à cause du nombre inégal d'observations entre les traitements pour chaque densité larvaire. En règle générale, la défeuillaison a été moindre dans les zones traitées que dans les zones non traitées, mais du point de vue statistique, il n'y avait pas tellement de différences. Dans les zones non traitées, le taux de survie des tordeuses du bourgeon de l'épinette jusqu'à leur métamorphose a varié selon les densités de populations aux premiers stades de développement larvaire et se situait entre 8 à 44% pour le sapin baumier et entre 5 et 25% pour l'épinette noire/rouge. Les diminutions du taux de survie dans les zones traitées ne sont pas présentées, étant donné qu'elles n'ont pas été utilisées comme mesure de l'efficacité du programme.

Les relevés aériens et les évaluations au sol qui ont été effectués après l'arrosage ont révélé que dans les plus grandes zones attaquées, bien délimitées, environ 0,73 million d'hectares avaient subi une défeuillaison allant de grave à modérée. Des observations sporadiques effectuées au sol à des endroits très différents ont révélé des ravages plus importants, mais il a paru peu pratique de faire des calculs de la zone victime de défeuillaison.

D'après le relevé des masses d'oeufs, environ 3,57 millions d'hectares devraient connaître une infestation allant de modérée à grave en 1985. Les coefficients de danger attribués aux parcelles échantillonnées ont indiqué une amélioration générale de l'état des arbres, comme le démontre une diminution de 17% par rapport à 1983 de la proportion des parcelles-témoins classées dans les catégories modérée à plus élevée. Cette amélioration a été attribuée à l'effet combiné du traitement et de facteurs naturels dans les zones traitées et à des facteurs naturels dans les zones non traitées, y compris un bon développement des pousses et un nombre moins imposant de larves rongeant les bourgeons en 1984.

CONCLUSIONS

Opérations d'arrosage

Les insecticides ont été épandus à l'intérieur de la période prévue pour l'arrosage des larves. Les intervalles entre les traitements chimiques ont été plus longs dans le cas des opérations effectuées par les petits appareils que dans le cas des opérations effectuées par des appareils T.B.M. Il en a été de même pour les traitement consistant en une seule application de B.t.

Les critères phénologiques et biologiques retenus en 1984 pour déterminer le calendrier d'intervention du programme d'arrosage ont semblé suffisants pour établir à quel moment les zones d'arrosage étaient prêtes à être traitées pour la première fois, d'après l'usage courant.

Efficacité du programme

Sur tout le territoire de la province, les objectifs du programme en matière de rétention du feuillage ont été atteints puisque, dans la plupart des zones traitées, le sapin baumier a conservé 60% ou plus de son feuillage de l'année tandis que l'épinette noire/rouge en a conservé 50% ou plus.

Presque toutes les parcelles (plus de 90%) ont atteint les objectifs du programme en matière de rétention du feuillage pour le sapin baumier et l'épinette noire/rouge, bien que dans certains cas la défeuillaison ait dépassé les limites escomptées. Dans de nombreuses parcelles-témoins non traitées (composées à 75% de sapin baumier et à 98% d'épinette noire/rouge), les niveaux de défeuillaison se sont aussi maintenus à l'intérieur des limites acceptables, ce qui a caché les bienfaits du traitement.

Les recensements effectués avant le traitement ont révelé des densités larvaires inégales variant entre 0 à 19 larves par branche de 45 cm, autant dans les territoires non traités que dans les zones traitées.

En 1984, comparativement à 1983, les probabilités de rétention d'un pourcentage précis du feuillage étaient plus fortes en l'absence de tout traitement du sapin baumier et de l'épinette noire/rouge. Lorsque des données semblables sur les "probabilités" de rétention pour les parcelles traitées ont été comparées aux données disponibles pour les zones non traitées, on s'est rendu compte qu'il était plus probable d'atteindre les niveaux de rétention du feuillage prévus dans les zones traitées, ce qui démontre ainsi les bienfaits du traitement. Cependant, il a été impossible d'obtenir des différences semblables entre les traitements à cause du nombre irrégulier de parcelles pour chaque densité larvaire.

Pour ce qui est du sapin baumier, les degrés moyens de défeuillaison dans les parcelles traitées ont été inférieurs, à tous les niveaux de population, à ceux des parcelles non traitées, indépendamment du genre d'appareil et de traitement, bien qu'il n'y ait pas eu tellement de différences entre les traitements (y compris les contrôles).

En outre, pour ce qui est de l'épinette noire/rouge, les degrés de défeuillaison moyens entre les traitements n'étaient pas tellement différents.

Dans les parcelles non traitées, la survie naturelle des tordeuses du bourgeon de l'épinette jusqu'à leur métamorphose a varié selon les densités de populations aux premiers stades de développement larvaire et se situait entre 8 et 44% pour le sapin baumier et entre 5 à 25% pour l'épinette noire/rouge.

Les observations météorologiques faites dans toute la province ont révélé qu'en 1984, comparativement à 1983, il y a eu plus de chutes de pluies et de journées pluvieuses pendant les derniers stades du développement larvaire. Ces conditions ont probablement intensifié les bienfaits du programme d'arrosage de 1984 en favorisant le développement de nouvelles pousses sur les arbres attaqués par la tordeuse tout en nuisant au cycle d'alimentation des larves.

Les relevés aériens et les évaluations au sol qui avaient pour but de déterminer le degré de défeuillaison ont révélé qu'en 1984, sur tout le territoire de la province, près de 0,73 million d'hectares de forêt avaient subi des défeuillaisons allant de modérées à graves.

Prévisions

D'après le relevé des masses d'oeufs effectué en 1984, environ 3,57 millions d'hectares devraient encore être infestés en 1985.

Des calculs des coefficients de danger établissant l'état général des arbres et la menace possible que représente la tordeuse du bourgeon de l'épinette ont révélé qu'en général, la situation s'était améliorée, comme le démontre une diminution de 17% par rapport à 1983 de la proportion des parcelles-témoins classées dans les catégories modérées, élevées et extrêmes. Cela signifie donc pour de grands territoires des niveaux de défeuillaison peu élevés, un excellent développement des nouvelles pousses et un bon potentiel de récupération au cours de l'été 1985.

RECOMMANDATIONS

Il est prévu qu'une plus grande proportion des programmes d'arrosage seront effectués par des petits avions prévus à cette fin plutôt que par des appareils TMB. Si l'on augmente le nombre de "petites parcelles", les problèmes d'ordre logistique seront plus complexes. Étant donné qu'en 1984, les intervalles entre les traitements effectués par les "petits appareils" ont été plus longs que lorsque des appareils plus gros ont été utilisés, il importe que la principale société responsable, Forest Protection Limited, rassemble un nombre suffisant d'appareils et exerce un contrôle strict sur la logistique des opérations afin de s'adapter facilement aux circonstances.

Les critères biologiques et phénologiques retenus en 1984 pour déterminer le calendrier d'intervention du programme d'arrosage semblent acceptables, d'après l'usage courant. Ces critères doivent donc être adoptés jusqu'à ce que des recherches sur "l'interface biologique" fournissent des directives pratiques qui permettront de raffiner et d'améliorer cet aspect des programmes d'arrosage.

Le relevé de 1984 sur la défeuillaison contenait des informations recueillies au cours d'évaluations au sol et de relevés aériens. Néanmoins, sur la carte obtenue, on semblait apercevoir des rayures est-ouest qui étaient sans doute attribuables en grande partie au relevé aérien. Il est recommandé d'essayer de survoler dorénavant des parcelles plus étroites et d'effectuer des évaluations au sol pour compléter au besoin les relevés aériens.

Les programmes de protection de la forêt contre la tordeuse du bourgeon de l'épinette sont implicitement à long terme et pourtant, chaque année, il faut vérifier leur efficacité. L'adoption de limites arbitraires en matière de rétention du feuillage est surtout basée sur l'intuition, bien qu'il y ait suffisamment de preuves pour confirmer que les ravages varient beaucoup d'une année à l'autre, même si les populations larvaires sont semblables, comme le souligne le présent rapport. De plus, les seuils de tolérance établis pour la défeuillaison de chaque essence attaquée par la tordeuse varient en fonction d'un certain nombre de facteurs, y compris l'âge de l'arbre. C'est ainsi que la quantité de feuilles requise dans une année pour garder en vie des arbres adultes et très vieux est différente de celle qui est nécessaire, pendant la même période, pour maximiser l'augmentation du volume de feuilles des jeunes arbres faisant partie de peuplements denses ou clairsemés. Il faudrait donc établir comme objectifs annuels du programme de rétention du feuillage de l'année pour le sapin baumier et l'épinette noire/rouge d'adopter et de respecter des pourcentages respectifs de 60% et de 50%, à moins qu'à la suite de la réception de renseignements supplémentaires, certains changements apparaissent justifiés.

À cause des différences entre les essences attaquées par la tordeuse et du fait que le système actuel ne nous permet pas d'évaluer exactement le degré de la défeuillaison de l'année de l'épinette noire/rouge, il est recommandé d'envisager de remplacer ce système par un autre plus pertinent, et ce à compter de 1985.

On a de tout temps prédit les populations de la tordeuse du bourgeon de l'épinette en utilisant les données sur les masses d'oeufs recueillies au mois

d'août. Au Nouveau-Brunswick, on a déjà élaboré des méthodes pour déterminer les populations des tordeuses du bourgeon de l'épinette qui survivent à l'hiver (L2), et des événements récents survenus dans le Maine et au Québec confirment que cette méthode peut représenter une façon plus économique et sûre de faire des prévisions. Il est donc recommandé que le ministère des Ressources naturelles envisage de remplacer d'ici deux ans le relevé traditionnel des masses d'oeufs par un relevé L2 plus précis.

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PROTECTION SPRAYING AGAINST SPRUCE BUDWORM IN NEW BRUNSWICK - 1984

Aerial spray operations against spruce budworm (Choristoneura fumiferana (Clem.)) for forest protection in New Brunswick began in 1952 and have been conducted annually since then, except for 1959 (Irving and Webb, 1984). Benefits which had accrued from this effort up to 1976 were outlined in the "Task Force for Evaluation of Budworm Control Alternatives" which also evaluated strategies other than chemical spraying for forest protection (Baskerville, 1976). Although 8 more years have gone by, during which there was a major international Canada-United States (CANUSA) spruce budworm research effort, it is still acknowledged that aerial spraying is the only way to keep softwood trees alive and growing in the face of severe budworm infestation. Protection, however, is only one component of the overall Provincial forest management strategy which contains elements such as reforestation, thinning, and scheduled harvesting as well as other non-budworm related activities. Without protection, the goals of sustained yield and continued timber production would be impossible to achieve.

The only operational alternative to large-scale aerially applied chemical sprays is the bacterial insecticide Bacillus thuringiensis or B.t. Recent developments have led to more concentrated B.t. preparations and significant cost reductions (Carrow, 1983) which will probably lead to wider use of B.t. in budworm control operations in the future. At present there are still some technological problems associated with its aerial application. Also, its past efficacy has been more variable than chemical insecticides (Carrow, 1983). Cost, however, is the major obstacle to the large-scale use of B.t. to replace chemical insecticides in New Brunswick.

In 1984, approximately 1.03 million hectares of spruce budworm infested forest were aerially treated in New Brunswick. Two chemical insecticides and one B.t. product were used. This detailed report outlines the various surveys that were conducted to plan and conduct the operation and provides an evaluation of the success of the program in light of stated objectives for foliage protection. A forecast of the size of the infestation expected for 1985 is also presented as well as recommendations for future spray-related activities.

1. THE SPRAY OPERATION

Some of the information contained within this Section was taken from the '1984 PROGRAM REPORT' prepared by Forest Protection Limited (Irving,1984). Additional operational details are contained within that report.

1.1 Area Sprayed

The 1984 forest protection program against spruce budworm in New Brunswick covered approximately 1.03 million hectares which was about 30 percent less than the area treated in 1983. This program was developed by the Department of Natural Resources (DNR) through the N.B. Budworm Committee (NBBC) which was established in 1983. This Committee is a working group involving all Licensees, DNR (Head Office and Regions), Forest Protection Limited (FPL), the Federation of Woodlot Owners, Health N.B. and Environment N.B. The NBBC provides a mechanism whereby the sponsors of the program and the regulatory agencies can provide input as the program is being developed. Actual spray operations were conducted under the direction of FPL. In addition Forest Patrol Limited (J.D. Irving Ltd.), sprayed approximately 215 000 ha of Irving freehold land (Oxley, Pers. Comm.). The area actually sprayed by FPL represented 87% of the program originally proposed. Some areas were deleted before the program began and some were deleted for logistical and other reasons during the program.

Of the total area treated by FPL, 938 474 ha were in the industrial portion of the program, that is, spray areas located beyond the set-back zone of 1.6 km from year-round habitation. The balance, 92 078 ha, consisted of private woodlots and small industrial freehold blocks located within the set-back zone between 300 m and 1.6 km from year-round habitation. Figure 1 illustrates the distribution of treatment areas in 1984.

1.2 Insecticides

One biological and two chemical insecticides were used in the 1984 spray program. The chemicals used were fenitrothion (Sumithion)[1] and aminocarb (Matacil 180F).[2] The biological insecticide Thuricide 48LV[3] contained a type of bacteria called Bacillus thuringiensis var. kurstaki, commonly referred to as B.t.

Approximately 85 percent of the area was treated with a double application of fenitrothion or aminocarb in water-based formulations as recommended by the N.B. Budworm Committee and approved by Environment N.B. Another 11.5 percent of the area

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Supplied by: 1. Sumitomo Canada Ltd.; 2. Chemagro Ltd.;
3. Zoecon Corporation.

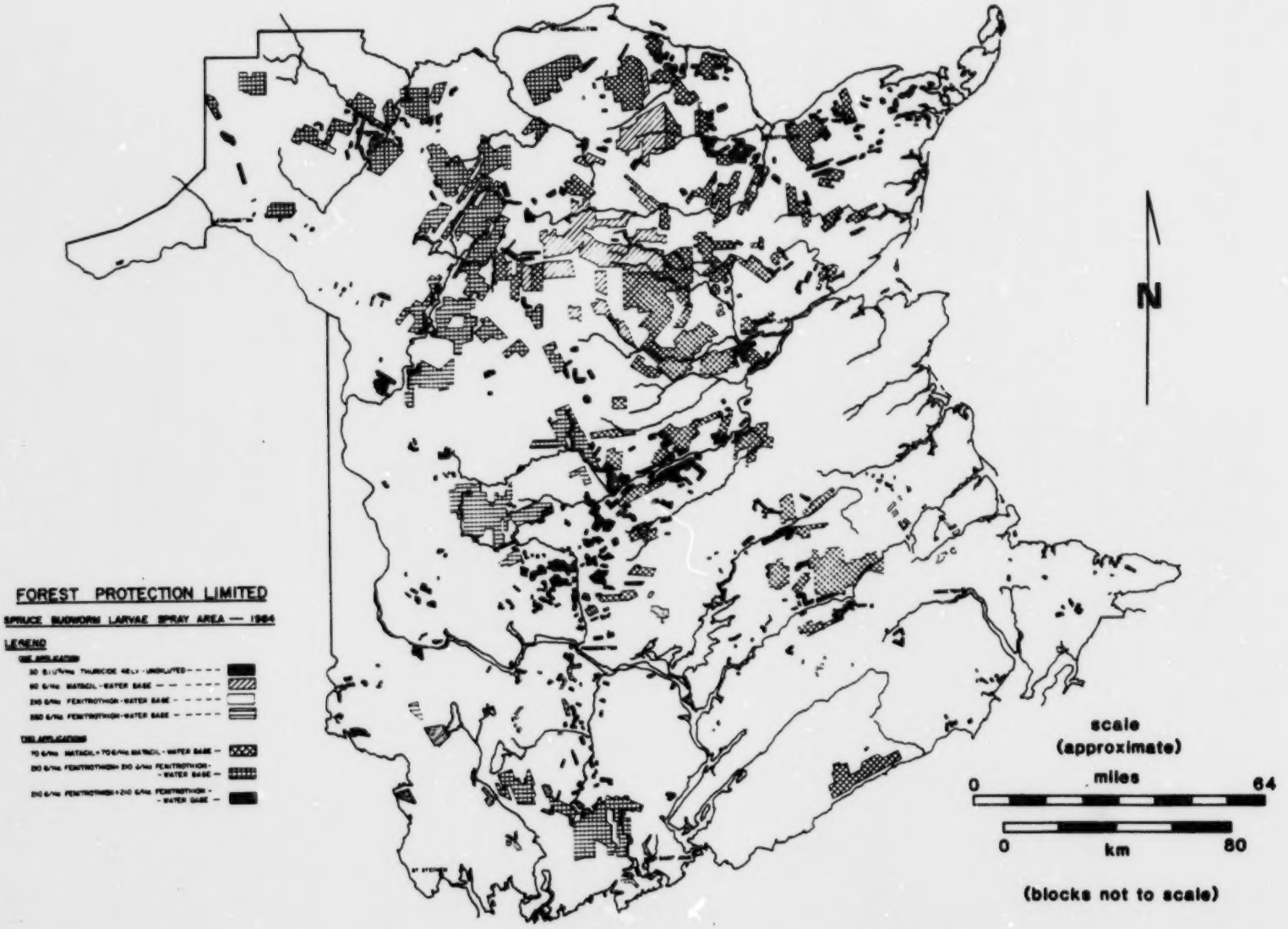

Figure 1. Map showing 1984 spruce budworm spray program in New Brunswick. (Detailed larger scale maps available at DNR).

received only a single application of aminocarb in water-based formulation, and the remaining 3.5 percent (37 300 ha) received the prescribed single treatment of undiluted B.t. Table 1 summarizes the area treated by insecticide, application rates, formulations, and aircraft type used for spraying.

1.3 Operational Logistics

On May 26, FPL was advised by DNR that certain spray blocks were biologically ready for treatment with chemical insecticide. This date was somewhat later than normal due to the cool spring weather which was experienced in 1984. Up to May 23, heat accumulation was slower than in the years 1979-83 (Figure 2). By early June, however, degree day accumulation had become more normal. Spray operations commenced from one airport (Grafton) on May 26, and all airstrips terminated operations on June 21.

The time period during which spruce budworm larval spraying is conducted usually spans 20 to 25 days. For chemical insecticides, a double application is normally prescribed with at least 5 days between treatments. This is to improve spray efficacy and is in accordance with Federal and Provincial regulations which require at least 5 days between applications of these insecticides to minimize any possible environmental damage. B.t. is applied in a single application, but with a later timing (see Section 2.1). By June 10, weather delays which were being experienced made it apparent that there would not be sufficient time to complete all the double chemical applications within the desired time. Consequently, approximately 117 800 ha (11.5 percent of the total program) were treated with a single application of Matacil at the maximum permissible single dosage (90 g/ha).

Delays between block openings and first or second application were examined. This information is beneficial in evaluating operational logistics and also spray efficacy. Table 2 indicates that for the TBM blocks sampled, 80 percent received their first treatment within 4 days of opening and 90 percent within 6 days. For small aircraft blocks, however, only 43 percent received first application within 4 days of opening, 63 percent within 6 days and 87 percent within 8 days. Hence the period over which the small blocks were sprayed was more protracted.

Table 3 summarizes the interval between first and second applications of chemical insecticides. For both TBM and small aircraft blocks sampled the majority were treated within 10 days of the first treatment, i.e. within 5 days after the required minimum 5-day interval.

Table 4 summarizes the total time taken to apply both chemical applications to the selected blocks. Ninety percent of the TBM blocks were completed within 12 days of opening, whereas there was a more protracted period to complete small aircraft blocks. Nevertheless, it appears that in 1984 the overall appli-

Table 1. Area sprayed (ha and ac) in New Brunswick in 1984 by insecticide, application rate, formulation, and aircraft type (from Irving, 1984).

Application Rate	Hectares (Thousands)	Acres (Thousands)	Aircraft Type
One Application			
(a) 210 g/Sumithion/ 1.46 L/ha (Dowanol, Atlox 3409F and Water)	0.6	1.4	Ag Truck, Brave
(b) 280 g/Sumithion/ 1.46 L/ha (Dowanol, Atlox 3409F and Water)	0.4	1.1	Ag Truck
(c) 30 B.I.U./Thuricide 48LV 2.35L/ha (undiluted)	37.3	92.1	TBM, Ag Truck, Brave, Pawnee, Bell 206,* Hiller 12E*
(d) 90 g/Matacil 180F/ 1.46 L/ha (Atlox 3409F and Water)	117.8	291.2	TBM, Ag Cat
Sub-total	156.1	385.8	
Two Applications			
(a) 70 g/Matacil 180F/ 1.46 L/ha + 70 g/ Matacil 180F 1.46 L/ha (Atlox 3409F and Water)	386.8	955.9	TBM, Ag Cat
(b) 210 g/Sumithion/ 1.46 L/ha + 210 g/ Sumithion/1.46 L/ha (Dowanol, Atlox 3409F and Water)	487.6	1204.8	TBM, Ag Cat, Ag Truck Brave, Pawnee, Hiller 12E*
Sub-total	874.4	2160.7	
Grand Total	1030.5	2546.5	

*helicopters

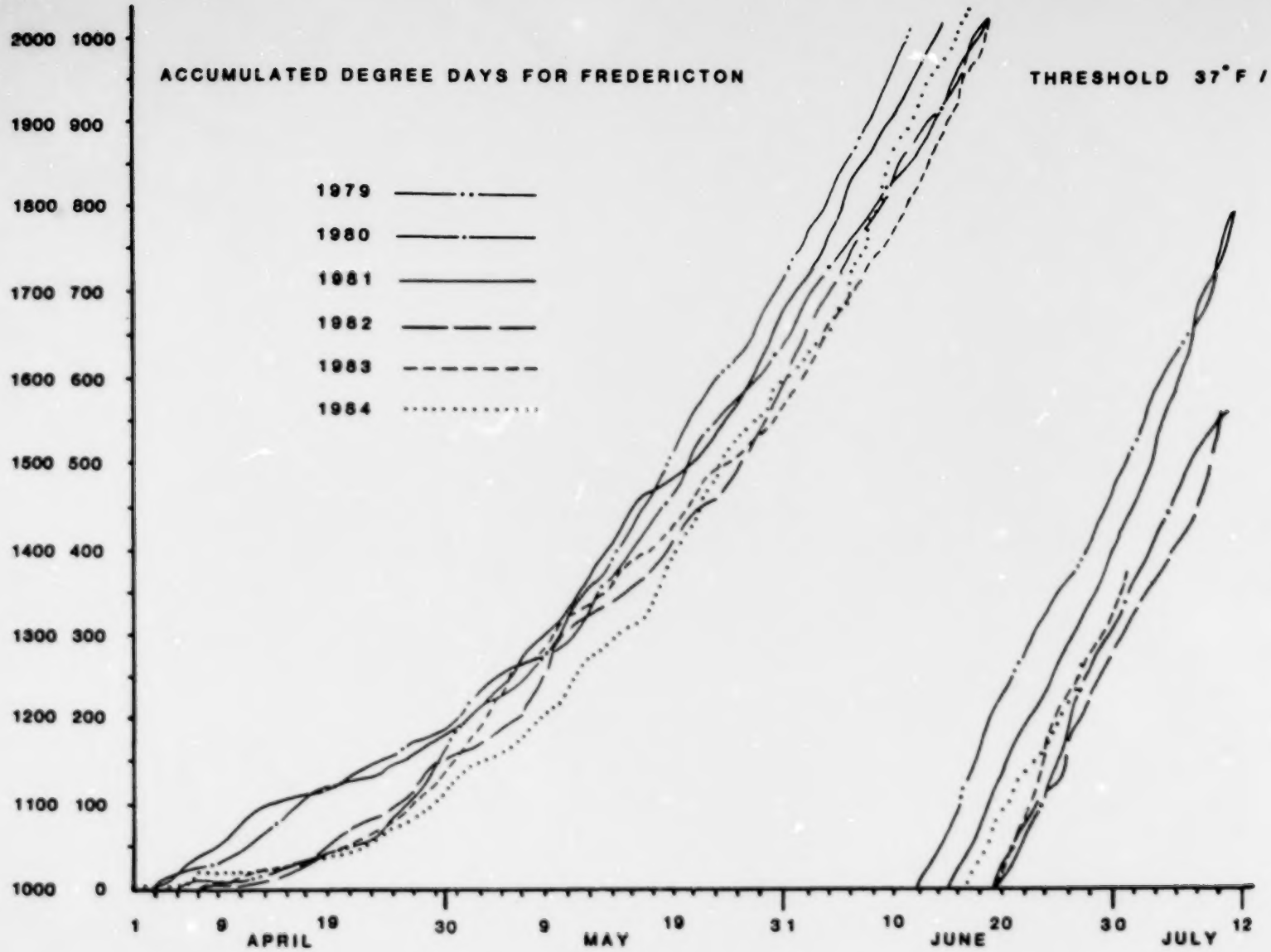

Figure 2. Comparison of accumulated degree days (threshold $37^{o}/2.78^{o}C$) for Fredericton from 1979 to 1984.

Table 2. Number of days delay from block opening to initial spray within sampled blocks in each treatment.

Delay (days)	Treatment						
	IBM				Small Aircraft		
	2xFen.	2xMat.	1xMat.	1xB.t.	2xFen.	2xMat.	1xB.t.
0-2	0	21	0	1	28	4	1
3-4	13	10	0	0	9	3	2
5-6	4	0	1	0	11	1	10
7-8	0	0	2	0	19	0	7
9-10	0	0	3	1	4	0	2
11	0	0	0	0	0	0	9
Total no. blocks	17	31	6	2	71	8	30

Table 3. Number of days between first and second chemical treatments within sampled blocks.

Spray Interval (days)	Treatment			
	IBM		Small Aircraft	
	2xFen.	2xMat.	2xFen.	2xMat.
5*- 6	2	6	12	0
7- 8	11	18	28	1
9-10	2	6	22	6
11-12	1	1	7	1
13-14	0	0	2	0
15+	1	0	0	0
Total no. blocks	17	31	71	8

* 5 days = required minimum interval between applications

cation of treatments was made within the time limits considered acceptable for spruce budworm larval spraying. If, however, there is a substantial increase in the number of small blocks to be treated in the future, then the number and distribution of small aircraft will require very close scrutiny to ensure that all areas will be treated in the desired time.

Table 4. Total number of days to complete both applications of each chemical treatment within sampled blocks.

	Treatment			
Total Time (days)	TBM		Small Aircraft	
	2xFen.	2xMat.	2xFen.	2xMat.
5*-6	1	1	2	0
7 -8	1	11	3	0
9 -10	7	10	22	0
11 -12	4	8	9	5
13-14	2	1	10	3
15-16	2	0	19	0
17-18	0	0	5	0
19-20	0	0	1	0
21+	0	0	0	0
Total No. Blocks	17	31	71	8

* 5 days = required minimum interval between application.

1.4 Costs

The report of the 1983 spruce budworm protection program in New Brunswick (Hartling, 1984) outlined the method by which the overhead and operational spray costs are shared by the Provincial Government and forest industry sponsors. Table 5 presents a comparison of the 1984 spray costs (exclusive of overhead) for TBM chemical and B.t., as well as small spray aircraft chemical and B.t. Spraying with small aircraft was more costly than with TBMs and spraying with B.t. was more costly than spraying with chemicals.

Table 5. Spray costs (exclusive of FPL overhead charges) for the 1984 spruce budworm protection program in N.B.

Treatment	Cost ($/ha)	Cost($/ac)
TBM chemical	6.80	2.75
TBM B.t.	11.79	4.77
Small aircraft chemical	11.52	4.66
Small aircraft B.t.	16.38	6.63

2. SURVEYS AND ASSESSMENTS

In 1984, DNR assumed full responsibility for all operational surveys and assessments of the budworm spray program and forecasts following the transition year of 1983 in which DNR received the technical assistance of the Canadian Forestry Service. The following surveys and assessments were conducted by DNR:

(1) Spray timing

(2) Pre-spray population checks

(3) Post-spray population checks

(4) Post-spray defoliation assessment - ground checks

(5) Aerial defoliation survey

(6) Egg-mass and hazard survey

(7) L2 (overwintering larval) survey

2.1 Spray Timing

One requirement within a spruce budworm forest spray program is a monitoring system to determine the optimum time to commence treatment and also to determine when treatment will no longer achieve desired results. Consequently, a sampling system was implemented in treatment blocks and check areas to monitor budworm larval development and behaviour as well as shoot development on host trees - balsam fir (Abies balsamea (L.) Mill.)) and red-black spruce (Picea rubens Sarg.-P. mariana (Mill.) B.S.P.). Because of differences between flushing rates of spruce and balsam fir and because of the use of chemical and biological insecticides, different criteria for timing were necessary. Although white spruce (P. glauca (Moench) Voss) was monitored in some blocks, no blocks were "timed" on this species. Figure 3 shows the traditional phenological zones for timing spruce budworm spray operations in New Brunswick (Webb, 1958; MacDonald, 1963).

In 1984, the Province was also sub-divided into a Fir Timing Zone and a Spruce Timing Zone (Figure 4) to reflect the major host type present in each zone. Only balsam fir was used for timing in the Fir Timing Zone and only red-black spruce was used for timing in the Spruce Timing Zone. Budworm development (from second instar to adult stage) was followed by determining the Index of Larval Development (Dorais and Kettela, 1982). In addition, larval behaviour was observed to determine the earliest time budworm larvae would be exposed and vulnerable to insecticide. Larvae were therefore recorded as being in hibernation, needle mining, wandering, in buds (or new shoots), or in male flowers. Tree phenology was also observed and recorded as an Index of Shoot Development (Dorais and Kettela, 1982) to describe the general progress of flushing. Class 1 referred to the con-

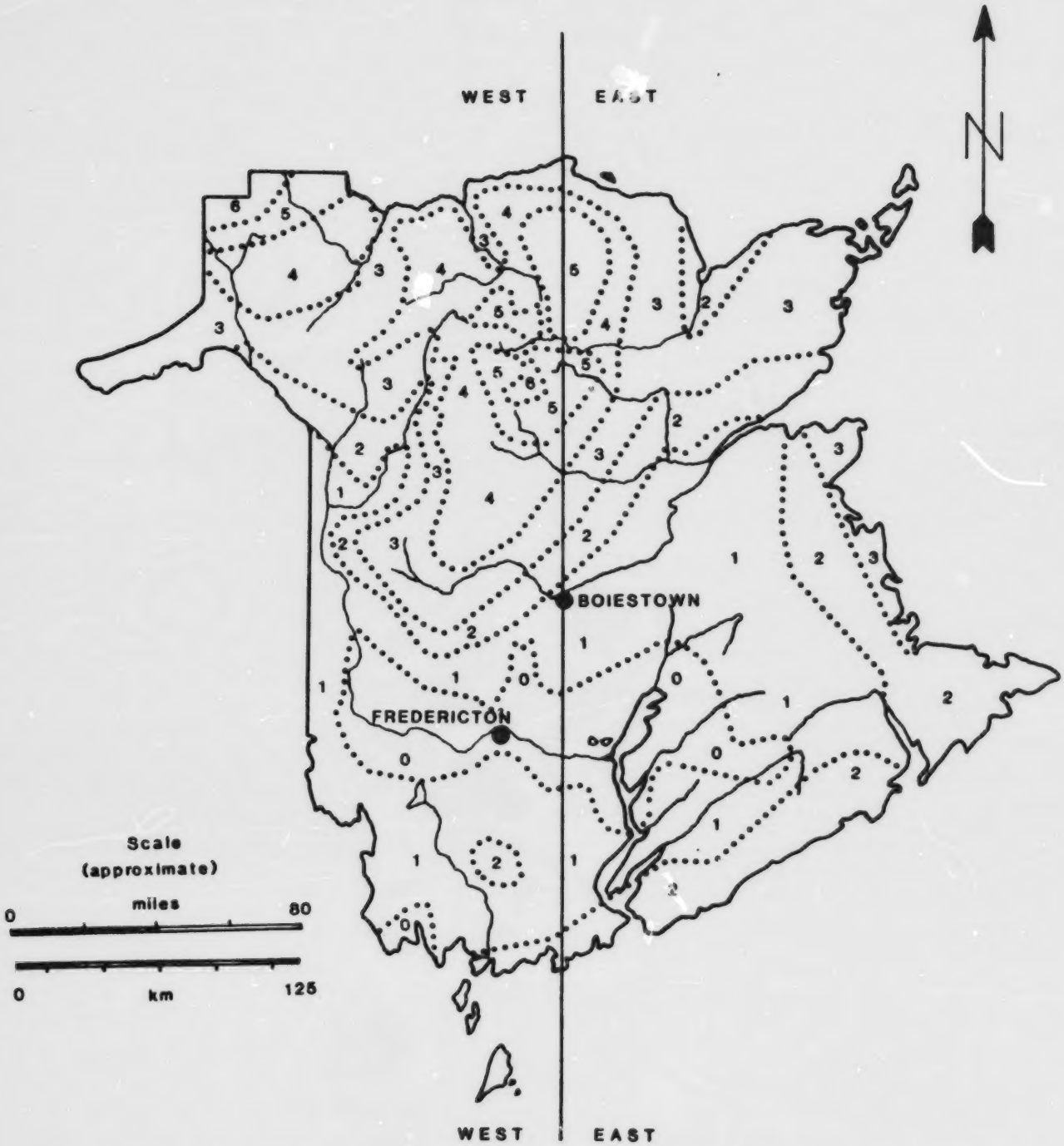

Figure 3. Map showing phenological contours in New Brunswick.

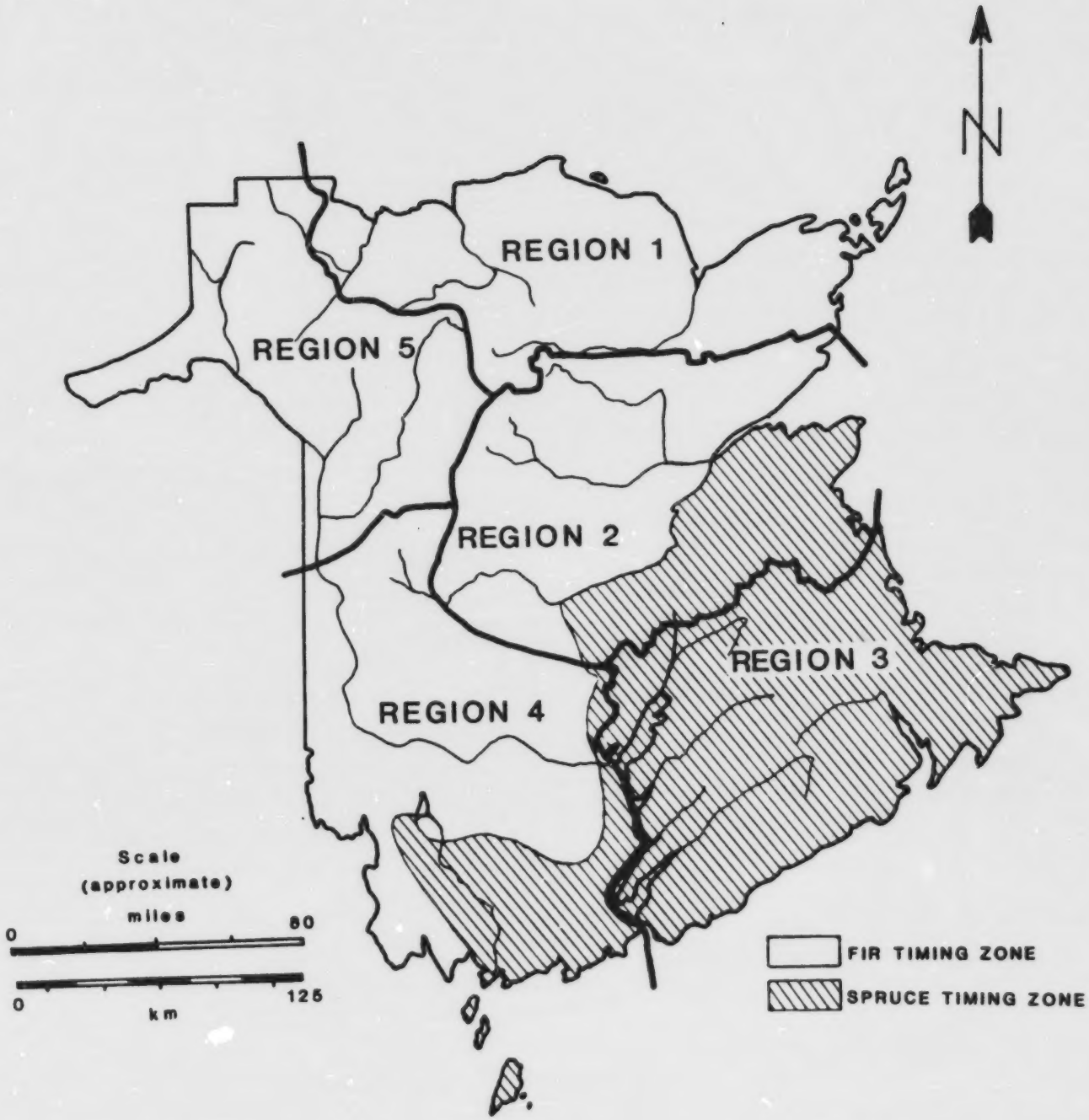

Figure 4. Map showing DNR's administrative Regions and the Fir Timing Zone and Spruce Timing Zone selected for the 1984 spray program.

dition where buds were resinous and enveloped in the bud membrane (scales). Class 5 referred to complete bud flush with elongated shoots.

In the Fir Timing Zone, blocks to be treated with chemical insecticide were said to be biologically 'open' or ready for treatment when buds on balsam fir trees were beginning to flush (Classes 3-4). At that time, budworm larvae were generally out of needle mines and wandering or establishing themselves on new shoots which became the target for insecticide deposit. The larvae were then deemed to be vulnerable to the chemicals through contact or by ingestion. For B.t. applications in this Zone, timing was delayed until fir shoots were more fully flushed (Classes 4-5) since B.t. must be ingested by the larvae to be effective, and greater shoot flushing increased the target area available for spray deposit. As with chemical treatments, the larvae had to be out of mined needles and wandering or establishing themselves on new shoots for these blocks to be opened.

In the Spruce Timing Zone, the Index of Shoot Development was recognized to be of limited benefit because of the much slower rate of flushing of red-black spruces compared to balsam fir. In fact, observations in 1983 revealed that equivalent 'classes' on red-black spruce were not reached until several weeks after balsam fir. Consequently, the criteria for timing for chemical applications on red-black spruce was that the larvae had reached peak third instar and a high proportion were wandering on the branch tips. For B.t. applications in this Zone, timing was delayed until bud break (about Class 2) on red-black spruce.

Examples of the relationships between insect behaviour, larval and shoot development for 1984 are presented in Figure 5 for fir timing and in Figure 6 for spruce timing for phenological zones Zero West (0W) and Zero East (0E). Development graphs for phenological zones 1 through 6 are given by Fir and Spruce Timing Zones in Figures A1 to A13 in the Appendix.

For background reading on the 'biological interface' or relationship between spray deposition and larval mortality the reader is referred to Varty and Godin (1983).

2.2 Pre-spray Population Checks

In addition to monitoring tree and larval development and behaviour, a substantial effort was placed on determining pre-spray population levels in treatment blocks and check areas. Each plot consisted of single 45-cm branch tips taken from the mid-crown sections of 3 balsam fir and 3 red-black spruce (or 3 white spruce if present). Based on past experience, the number of early instar larvae that were present provided an indication of the relative severity of defoliation expected if treatments were not applied. In the past, pre-spray sampling made it possible to delete areas from the spray program where samples were consistent-

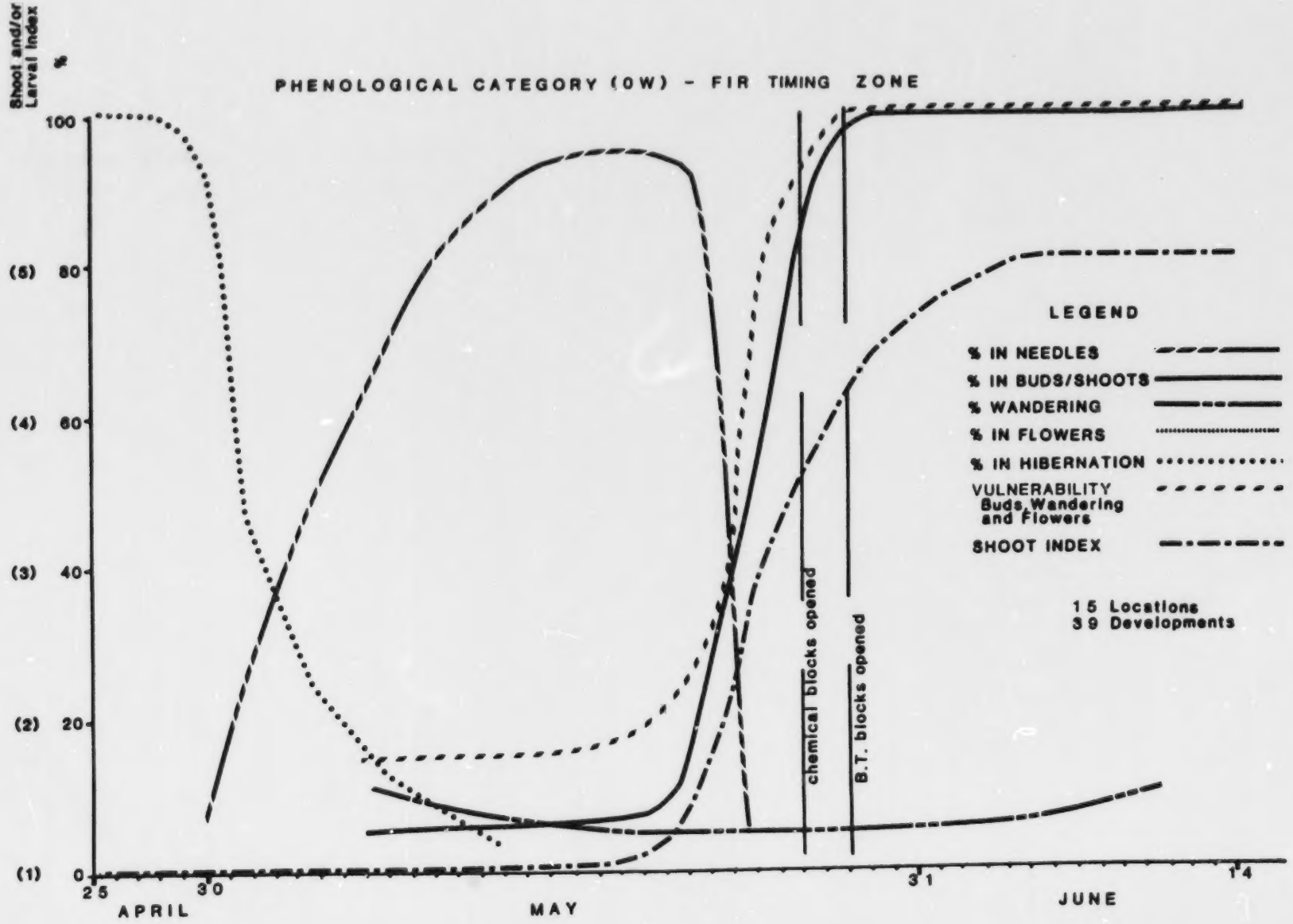

Figure 5. Relationships between larval behaviour and shoot development on balsam fir in phenological category OW in the Fir Timing Zone in 1984.

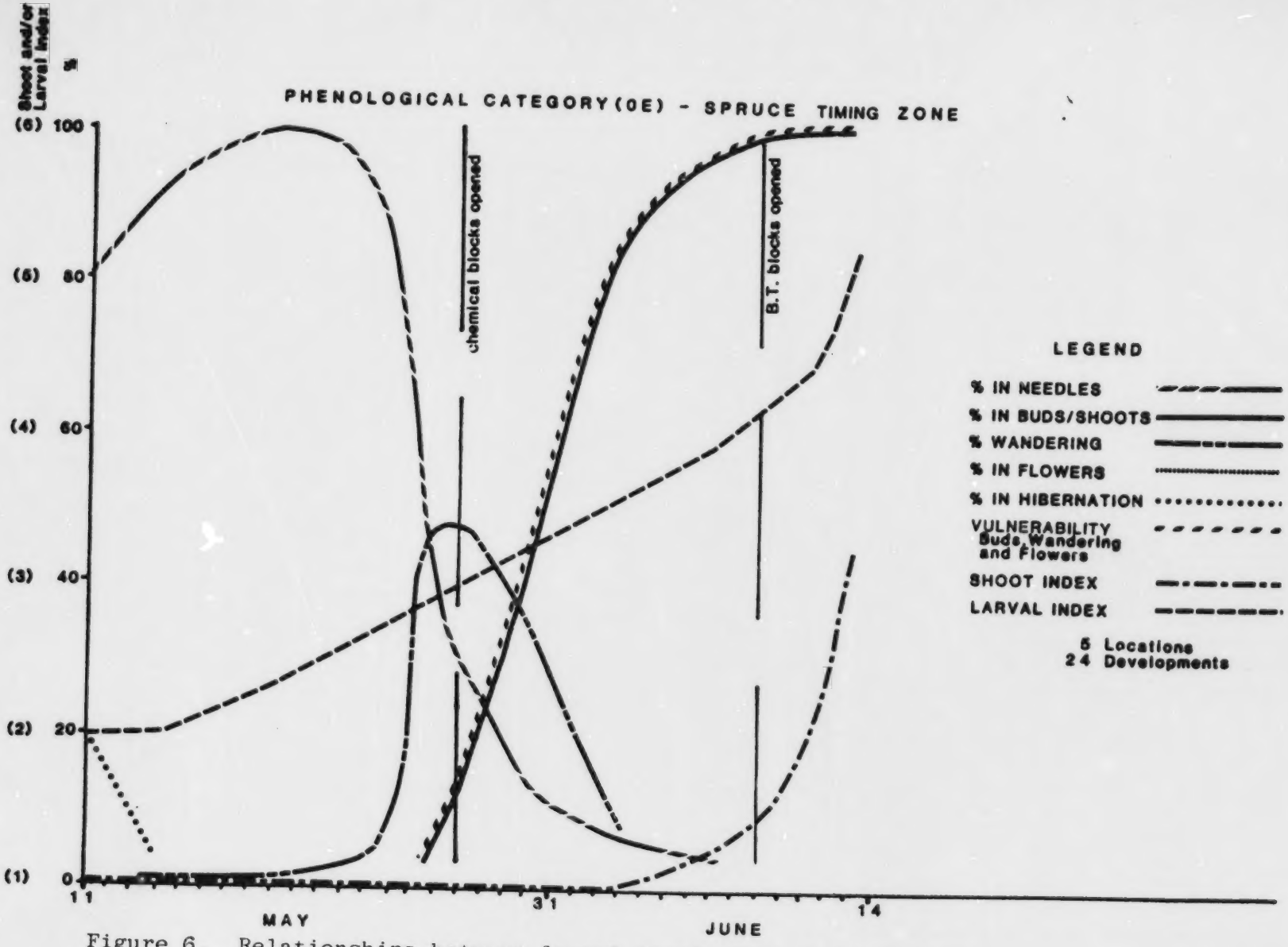

Figure 6. Relationships between larval development and behaviour, and shoot development on red-black spruce in phenological category OE in the Spruce Timing Zone in 1984.

ly found to be low (i.e. generally fewer than 3-5 larvae per 45-cm branch tip) throughout the target area since defoliation usually does not exceed about 30 percent at these larval densities.

Results from this effort in 1984 revealed extreme variability in pre-spray population levels between plots within spray blocks and check areas and although there were substantial numbers of plots in the lower range, these were generally interspersed with plots having moderate to high larval counts. This suggested that variable defoliation levels could be expected but made it very difficult to conclude that population levels were sufficiently low to warrant deleting areas from the spray program. Table 6 summarizes the sampling intensity throughout the program and Table 7 summarizes pre-spray larval population levels from treated and untreated plots. Regional summaries are presented on a block and plot basis in Tables A1 and A2 respectively in the Appendix.

2.3 Post-spray Population Checks

Two types of post-spray population checks were incorporated into the spray program sampling scheme. As time permitted, samples were taken within several days after the first application of chemical insecticide to determine whether larval populations had been reduced enough to recommend that a second application was unnecessary. Such was not the case in the 1984 program because of the extreme variability of the data and limited time to do intensive re-checks. Continued checks of larval development on each host species provided information to determine when it was too late to continue spraying in any given area and hence terminate the operation.

Additional sampling of post-spray larval populationscontinued after spray operations had ceased. This was conducted in conjunction with larval development work used to determine when larvae had finished feeding and entered the pupal stage. At this stage, a post-spray pupal survey was conducted. These data made it possible to calculate normal survival to the pupal stage in untreated check areas as well as the reduction in survival due to treatment (i.e. insecticide-induced mortality) in treated areas. Although population reduction due to treatment could thus be calculated (Abbott, 1925), these results were not regarded as a measure of efficacy. Efficacy was measured in terms of the foliage protection objectives (Section 3.1). In other words, a 90 percent insect kill at the early larval stages could equate very well with foliage protection. On the other hand, since late-instar larvae cause most defoliation beyond the bud mining stage, a 90 percent late-instar insect kill may have little benefit in foliage protection, though it might have some influence on local populations (barring female moth invasion). Therefore, larval mortalities due to treatment were not presented in this report. Natural survival, however, varied with early larval densities and ranged from 8 to 44 percent on balsam fir and from 5 to 25 percent on red-black spruce.

Table 6. Summary of sampling intensity within DNR Administrative Regions, treatments, host, and relationship to the total number of blocks sprayed.

Region*	Aircraft & Treatment**	Number of Sample Plots: Balsam Fir	Red-Black Spruce	White Spruce	No. of Blocks Sampled	No. of Blocks Sprayed	% Spray Blocks Sampled
1	a)Controls	203	119	28	8	-	-
	b)TBM-2xFen.	54	21	30	2	7	29
	TBM-2xMat.	179	176	21	11	14	79
	TBM-1xMat.	146	89	32	4	6	67
	Totals	379	286	83	17	27	63
	c)SM-2xFen.	133	64	38	12	93	13
	SM-2xMat.	10	4	5	1	1	100
	SM-1xB.t.	20	9	0	1	1	100
	Totals	163	77	43	14	95	15
2	a)Controls	77	170	0	10	-	-
	b)TBM-2xFen.	28	27	0	1	4	25
	TBM-2xMat.	343	372	5	15	23	65
	TBM-1xMat.	58	49	0	2	4	50
	Totals	429	448	5	18	31	58
	c)SM-2xFen.	158	161	5	15	63	24
	SM-2xMat.	36	65	2	7	12	58
	Totals	194	226	7	22	75	29
3	a)Controls	36	51	0	2	-	-
	b)TBM-2xMat.	46	82	1	4	9	44
	c)SM-2xFen.	109	190	1	20	70	29
	SM-1xB.t.	45	31	1	5	25	20
	Totals	154	221	2	25	95	26
4	a)Controls	92	64	3	7	-	-
	b)TBM-2xFen.	73	136	2	7	9	78
	TBM-2xMat.	20	29	0	1	2	50
	TBM-1xB.t.	47	39	0	2	2	100
	Totals	140	204	2	10	13	77
	c)SM-2xFen.	191	183	11	20	98	20
	SM-1xB.t.	178	190	9	24	85	28
	Totals	369	373	20	44	183	24

Table 6. (Continued).

Region*	Aircraft & Treatment**	Number of Sample Plots: Balsam Fir	Red-Black Spruce	White Spruce	No. of Blocks Sampled	No. of Blocks Sprayed	% Spray Blocks Sampled
5	a)Controls	16	11	3	5	-	-
	b)TBM-2xFen.	162	81	35	6	18	33
	TBM-2xMat.	0	0	0	0	3	0
	Totals	162	81	35	6	21	28
	c)SM-2xFen.	55	25	9	4	48	8
	SM-1xB.t.	0	0	0	0	2	0
	Totals	55	25	9	4	50	8
Provincial Totals							
	a)Controls	424	415	34	32	-	-
	b)TBM-2xFen.	317	265	67	16	38	42
	TBM-2xMat.	588	659	27	31	51	61
	TBM-1xMat.	204	138	32	6	10	60
	TBM-1xB.t.	47	39	0	2	2	100
	Totals	1156	1101	126	55	101	55
	c)SM-2xFen.	646	623	64	71	372	19
	SM-2xMat.	46	69	7	8	13	62
	SM-1xB.t.	243	230	10	30	113	27
	Totals	935	922	81	109	498	22

* Regions = DNR Administrative Regions as shown in Figure 4.
** Controls = Untreated check areas.
SM = small spray aircraft.
TMB= TBM spray aircraft.

Table 7. Summary of plot sampling intensity by host species, treatment, and pre-spray larval density.

Host Species	Aircraft-Treatment	Plots Lost[a]	Number of Plots Sampled (Pre-spray larvae/45-cm tip) (0-9)	(10-19)	(20-29)	(30-39)	(40+)	Total	Def. Only	Grand Total
balsam fir	Controls	5	267	120	25	6	1	419	0	424
	(%)		(64)	(29)	(6)	(1)	(1)	(100)		
	TBM-2xFen.	4	152	107	16	4	0	279	34	317
	TBM-2xMat.	4	149	107	25	1	3	285	299	588
	TBM-1xMat.	0	21	12	11	5	1	50	154	204
	TBM-1xB.t.	0	22	6	1	0	0	29	18	47
	Sub-totals	8	344	232	53	10	4	643	505	1156
	(%)		(53)	(36)	(8)	(2)	(1)	(100)		
	SM[b]-2xFen.	4	103	63	10	3	0	179	463	646
	SM -2xMat.	0	16	8	0	1	0	25	21	46
	SM -1xB.t.	5	95	85	16	4	1	201	37	243
	Sub-totals	9	214	156	26	8	1	405	521	935
	(%)		(53)	(39)	(6)	(2)	(1)	(100)		
	Irving[c]	0	0	0	0	0	0	0	313	313
	Totals[d]	22	825	508	104	24	6	1467	1339	2828
	(%)		(56)	(35)	(7)	(2)	(1)	(100)		
red-black spruce	Controls	5	192	148	54	13	3	410	0	415
	(%)		(47)	(36)	(13)	(3)	(1)	(100)		
	TBM-2xFen.	3	99	62	11	5	3	180	82	265
	TBM-2xMat.	3	115	125	46	7	3	296	360	659
	TBM-1xMat.	0	6	11	6	1	1	25	113	138
	TBM-1xB.t.	0	8	13	4	2	0	27	12	39
	Sub-totals	6	228	211	67	15	7	528	567	1101
	(%)		(43)	(40)	(13)	(3)	(1)	(100)		
	SM-2xFen.	0	55	69	22	9	22	177	446	623
	SM-2xMat.	0	11	11	2	0	0	24	45	69
	SM-1xB.t.	9	54	70	37	16	8	185	36	230
	Sub-totals	9	120	150	61	25	30	386	527	922
	(%)		(31)	(39)	(16)	(6)	(8)	(100)		
	Irving	0	0	0	0	0	0	0	213	213
	Totals	20	540	509	182	53	40	1324	1307	2651
	(%)		(41)	(38)	(14)	(4)	(3)	(100)		

Table 7. (Continued)

Host Species	Aircraft-Treatment	Plots Lost[a]	Number of Plots Sampled (Pre-spray larvae/45-cm tip) (0-19)	(10-19)	(20-29)	(30-39)	(40+)	Total	Def. Only	Grand Total
white spruce	Controls	0	26	8	0	0	0	34	0	34
	(%)		(76)	(24)	(0)	(0)	(0)	(100)		
	TBM-2xFen.	0	34	27	1	3	0	65	2	67
	TBM-2xMat.	0	5	2	2	1	1	11	16	27
	TBM-1xMat.	0	0	0	0	0	0	0	32	32
	Sub-totals	0	39	29	3	4	1	76	50	126
	(%)		(51)	(38)	(4)	(5)	(1)	(100)		
	SM-2xFen.	0	3	3	2	1	1	10	54	64
	SM-2xMat.	0	5	0	0	0	0	5	2	7
	SM-1xB.t.	0	1	4	4	0	1	10	0	10
	Sub-totals	0	9	7	6	1	2	25	56	81
	(%)		(36)	(28)	(24)	(4)	(8)	(100)		
	Irving	0	0	0	0	0	0	0	63	63
	Totals	0	74	44	9	5	3	135	169	304
	(%)		(54)	(32)	(7)	(4)	(2)	(100)		

a - Plots lost = plots harvested prior to spraying.
b - SM = Small spray aircraft.
c - Irving = plots on Irving freehold sprayed by Forest Patrol Ltd.
d - Note totals are not cumulative between species because more than one species was sampled in mixed stands.

2.4 Post-spray Defoliation Assessment - Ground Checks

During the post-spray pupal survey, assessments of final current year's defoliation were made at the same sites initially sampled for pre-spray data within treated and untreated check areas. Additionally, as part of this survey it was decided to collect extra defoliation information from treatment blocks which had not originally been sampled in the pre-spray survey. In this way it was possible to increase the data base for determining the benefits of the program in terms of foliage protection objectives. This information, however, could not be used in deriving or examining any expected defoliation relationships because of the absence of pre-spray larval counts. The numbers and distribution of plots sampled to collect additional defoliation information are given in Table 7.

Ocular estimates of current defoliation were made by examining defoliation on sample trees as a whole and by examining defoliation levels on two 45-cm mid-crown branches from each tree. Assessments of current defoliation on balsam fir and white spruce were based on an 11-class system with 10-percent classes where class 11 indicated complete destruction of both the current year's needles and shoot axils. Red-black spruce defoliation on the other hand, was assessed using a 4-class system with 25-percent classes. The need for a better damage rating system on red-black spruce has been stressed by Trial (1984) and Spies (1984) who recognized that significant damage is caused through budmining before flushing occurs.

2.5 Aerial Defoliation Survey

An aerial defoliation survey is annually conducted in New Brunswick after the spruce budworm larvae have finished feeding and infested host trees have taken on a reddish-brown coloration that is characteristic of budworm feeding damage. These annual surveys provide extensive overviews of the distribution and severity of budworm feeding throughout the Province. In years when the survey is unhampered by adverse weather the survey can help in evaluating the success of spraying to limit defoliation within treatment areas. Trained observers in Cessna-type high-winged aircraft fly over the whole Province in east-west flight lines spaced approximately 5-km apart. Using base maps at a scale of 1in=3mi as navigational aids, the observers delineate areas where light, moderate, and severe levels of defoliation are observed.

The 1984 aerial survey was plagued by rain, high wind, and poor visibility (haze) during the optimum survey time. Nevertheless, the survey was conducted using 9 aircraft. To augment this effort, an extensive ground survey was conducted to examine tree defoliation levels at 5000 points across the Province. This information was used to help identify defoliated areas not detected from the air and to better define boundaries of defoliated stands.

The result of incorporating information from both these surveys was the production of a defoliation map indicating approximately 0.73 million ha of combined moderate and severe defoliation in 1984 (Figure 7). This total represented the larger, more well-defined areas of defoliation found throughout the Province compared to the 1983 estimate of 2.03 million ha of moderate and severe defoliation. Although light defoliation and isolated pockets of moderate and severe defoliation were also detected throughout the Province in 1984, no attempt was made to obtain area estimates because of the difficulty of putting boundaries around these point observations. Despite early concerns over the reliability of aerial survey results, a comparison of aerial and ground defoliation observations showed good general agreement with original aerial survey findings, though no attempt was made to use this information in relation to the spray program.

Referring to Figure 7, there was an apparent "striped" feature associated with the defoliation map. This was primarily due to the methods used to gather and interpret the information. Future surveys should consider the use of narrower flight paths to eliminate some of this artifact - recognizing, of course, that there will be limitations with adequate survey weather at the desired time and the availability of sufficient numbers of qualified observers.

2.6 Egg Mass and Hazard Survey

Spruce budworm egg mass and hazard surveys have been conducted annually throughout the Province to predict the severity and distribution of budworm populations and tree condition for the following year. These elements become the primary basis upon which protection programs for the ensuing year are initially designed. Methods and procedures that were used in egg-mass sampling and hazard rating were among those recently reviewed in Dorais and Kettela (1982). In 1984, a total of 1476 locations were sampled, slightly more than the 1316 locations sampled in 1983 and fewer than the 1753 and 1740 locations sampled in 1982 and 1981 respectively. The 1985 infestation and hazard forecasts from this study are presented in Section 4 of this report.

2.7 L2 Survey (overwintering larval survey)

Once budworm larvae emerge from eggs, they re-distribute themselves upon host trees seeking protective sites, such as old flower cups or bark crevices on the branches. Here they spin silken shelters called 'hibernaculae'. In these structures they molt to second instar larvae, or the L2 stage, and remain dormant during the winter. Samples may be taken during this L2 stage to refine infestation forecasts provided by the egg mass survey (Dorais and Kettela, 1982). Approximately 1500 L2 survey samples were taken during the winter of 1984-85. Additional L2 sampling can be used to define whether particular areas of special interest have high populations of budworm larvae and are in need of protection or whether they have low populations and may be deleted. This survey was to continue throughout the winter months hence results were not available for this report.

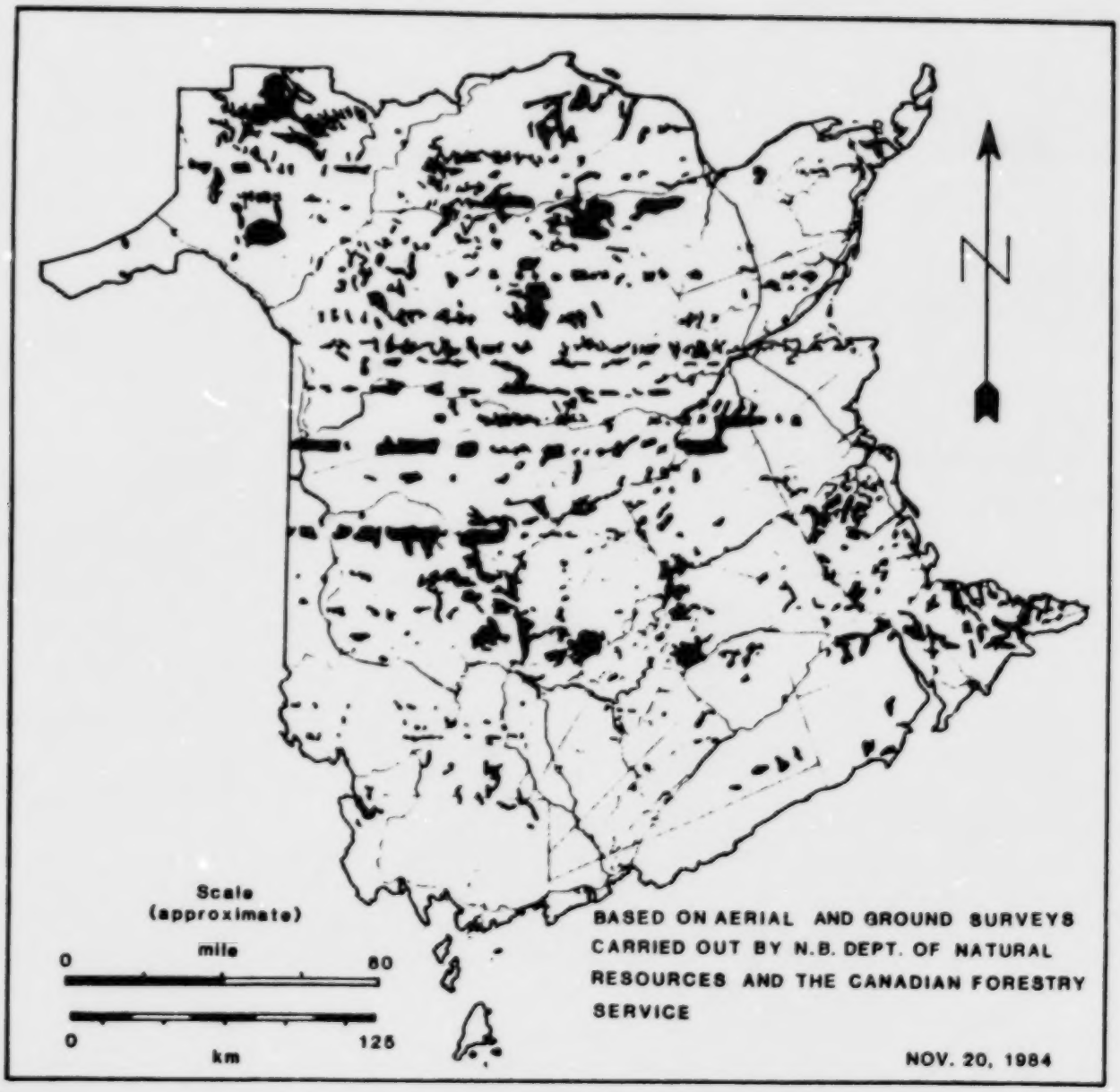

Figure 7. Map showing the area of moderate to severe defoliation in New Brunswick in 1984.

3. EFFECTIVENESS OF SPRAY OPERATIONS

3.1 Spray Program Objectives

Uncontrolled budworm feeding causes many adverse effects to host trees and forest stands including rootlet mortality and reduced vigor; increment loss and tree mortality; reduced cone and seed production; and regeneration problems. The severity of damage depends upon interactions between many factors including: tree age, tree vigor, stand composition, site, weather, and the intensity and duration of infestation. The main factor causing these adverse effects is the cumulative effect of defoliation of current year's and sometimes older classes of needles. The annual objective of the spray program therefore has been to reduce the numbers of feeding larvae on infested trees in target areas, or spray blocks, at an appropriate time to limit the severity of current year's defoliation. More specifically, the program's objectives were to retain 60 percent of the 1984 needle growth on balsam fir (and white spruce) and 50 percent of the 1984 needle growth on red-black spruce. Conversely, this meant limiting current defoliation to less than 40 and 50 percent on these species respectively. The reason for a more liberal objective on red-black spruces was their lower vulnerability (MacLean, 1980) and greater population threshold for equivalent defoliation. Because of the limited presence of white spruce in spray blocks, observations on this species were therefore limited, but nonetheless were included for discussion in some of the sections which follow.

3.2 Provincial Summary-Plots Meeting Objectives

Results from post-spray assessments indicated that all sampled blocks sprayed by TBM aircraft in the 1984 industrial program* had average defoliation levels which met program objectives by limiting current year's defoliation to 40 percent or less on balsam fir and 50 percent or less on red-black spruce regardless of treatment applied. On white spruce, however, average defoliation levels exceeded desired levels in one TBM block. Results of the small aircraft operation were also very successful though one block treated with fenitrothion and 2 blocks treated with B.t. had defoliation levels on balsam fir exceeding desired limits. Also, one small aircraft B.t. block had excessive defoliation on white spruce.

In spite of these successful overall results, it was determined from unsprayed control data that even in a high percentage of these selected areas average defoliation levels were also generally within desired limits. These observations supported the anticipated variability in defoliation levels which had

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*Note: Unlike the previous year, in 1984 some small blocks in the industrial zone (i.e. blocks located greater than 1.6 km from year-round habitation) were treated using with small aircraft as well as TBM aircraft.

been expected after preliminary examination of pre-spray larval counts. Thus the more salient benefits of treatment which were masked by these overall block summaries were more closely examined on a plot basis as follows.

Table 8 presents the overall Provincial summary of the percentage of sampled plots in each treatment within each defoliation category for each host species. Comparisons between all treatments were somewhat restricted because of differences between sampling intensity within each treatment and differences between pre-spray larval densities (Table 9). Nevertheless, on balsam fir and red-black spruce approximately 90 percent or more of the plots within each treatment met the program's objectives of retaining 60 or 50 percent or more of the current year's needles on each host species respectively. Results on white spruce were much less favourable though there were fewer observations. Results from extra defoliation sampling (blocks sampled in the absence of any pre-spray information) are also given in Tables 8 and A3 (Appendix) for comparison. These results also support the observations noted above. In contrast to these Provincial defoliation results, Regional defoliation results are summarized in Tables A4 and A5 of the Appendix.

In spite of the impressive numbers of treated plots that met program objectives, one must recognize that 75 percent of the balsam fir check plots, 98 percent of the red-black spruce check plots, and 79 percent of the white spruce check plots also showed defoliation levels within the stated program objective levels even though population levels were similar to those in treated areas. A combination of good foliage production by the trees and reduced budworm feeding were considered to account for this situation. It was also reasoned that these observations were influenced by cooler weather in the spring (Section 1.3) and more rainfall later in the summer during the major larval feeding period (Section 3.7).

3.3 Foliage Retention Probabilities in Untreated Plots

In the report on the 1983 spray program in New Brunswick (Hartling, 1984) it was pointed out that treatment efficacy cannot be fully examined in isolation from a measure of initial pest density. In other words, all things being equal with an increase in population density one would expect an increase in the likelihood of greater feeding damage occurring; or conversely, a reduction in the likelihood of a specified amount of foliage being naturally retained on infested branches. To illustrate this premise, a series of "probabilities"[1] for natural foliage retention were derived for different population levels and different host trees in unsprayed plots. That exercise confirmed the premise and also illustrated that a higher insect population threshold was needed

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[1] "probability" was defined as the percentage of plots sampled in which the amount of foliage retained was equal to or greater than the foliage retention level desired.

Table 8. Summary (percent of plots) of defoliation estimates made at plots sampled for pre-spray larval density (a) compared to estimates made at 'extra' plots that had no larval densities measured (b).

Host	% Def. Classes	Control	Treatment: TBM 2xFen.		2xMat.		1xMat.		1xB.t.		Small Aircraft 2xFen.		2xMat.		1xB.t.		Irving
		(a)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(b)
balsam fir	0-20	50	74	76	73	80	66	71	86	90	72	75	80	86	73	100	89
	21-40	25	20	21	18	12	24	19	14	11	19	17	16	14	16	0	8
	41-60	12	5	3	5	5	6	7	0	0	6	5	4	0	6	0	2
	61-80	10	1	0	3	2	4	3	0	0	3	3	0	0	4	0	1
	81-100	3	0	0	1	1	0	<1	0	0	0	<1	0	0	1	0	0
(no. of plots)		(419)	(279)	(34)	(285)	(299)	(50)	(154)	(29)	(18)	(179)	(463)	(25)	(21)	(201)	(37)	(313)
red-black spruce	0-25	78	87	84	78	91	100	90	96	100	85	93	100	98	91	100	97
	26-50	20	12	16	20	8	0	7	4	0	14	6	0	2	7	0	3
	51-75	2	1	0	1	<1	0	3	0	0	1	<1	0	0	2	0	0
	76-100	0	0	0	1	<1	0	0	0	0	0	<1	0	0	0	0	0
(no. of plots)		(410)	(180)	(82)	(296)	(360)	(25)	(113)	(27)	(12)	(177)	(446)	(24)	(45)	(185)	(36)	(213)
white spruce	0-20	32	23	50	36	69	0	50	0	0	90	63	60	100	70	0	79
	21-40	47	42	50	36	25	0	16	0	0	10	33	20	0	0	0	13
	41-60	15	23	0	18	0	0	16	0	0	0	4	0	0	30	0	5
	61-80	3	12	0	9	6	0	16	0	0	0	0	20	0	0	0	3
	81-100	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
(no. of plots)		(34)	(65)	(2)	(11)	(16)	(0)	(32)	(0)	(0)	(10)	(54)	(5)	(2)	(10)	(0)	(63)

Table 9. Percent of plots in each treatment within each pre-spray larval density range (number of larvae/45-cm branch tip) for each species.

Host	Larval Density	Control	Treatment: TBM 2xFen.	TBM 2xMat.	TBM 1xMat.	TBM 1xB.t.	Small Aircraft 2xFen.	Small Aircraft 2xMat.	Small Aircraft 1xB.t.
balsam	0-9	64	55	52	42	76	58	64	47
fir	10-19	29	38	38	24	21	35	32	42
	20-29	6	6	9	22	3	6	0	8
	30-39	1	1	1	10	0	2	4	2
	40+	1	0	1	2	0	0	0	1
(no. of plots)		(419)	(279)	(285)	(50)	(29)	(179)	(25)	(201)
red-	0-9	47	55	39	24	30	31	46	29
black	10-19	36	34	42	44	48	39	46	38
spruce	20-29	13	6	16	24	15	12	8	20
	30-39	3	3	2	4	7	5	0	9
	40+	1	2	1	4	0	12	0	4
(no. of plots)		(410)	(180)	(296)	(25)	(27)	(177)	(24)	(185)
white	0-9	77	52	45	0	0	30	100	10
spruce	10-19	23	42	18	0	0	30	0	40
	20-29	0	1	18	0	0	20	0	40
	30-39	0	5	9	0	0	10	0	0
	40+	0	0	9	0	0	10	0	10
(no. of plots)		(34)	(65)	(11)	(0)	(0)	(10)	(5)	(10)

on red-black spruce to cause approximately the same "classes" of defoliation as on balsam fir.

Similar calculations were made with the 1984 data and the results were compared to 1983 values (Figures 8 and 9). Due to a minor revision of defoliation class limits to coincide more closely with 1984's objectives, the foliage retention levels examined were slightly different from those the previous year. Nevertheless, some comparisons between years were made, as follows:

1. The trend of decreasing probabilities for specified levels of natural foliage retention on balsam fir was again evident across the range of larval populations encountered, but at much higher levels than last year (about 25 to 45 percent higher on average).

2. The higher population-defoliation thresholds for red-black spruce compared to balsam fir were again evident in 1984 though at much higher levels than in 1983.

3. Across the range of population densities recorded in 1984, there was a very high natural probability that 50 percent or more of the foliage on red-black spruce would have been retained without treatment. In fact, there was generally a greater-than-70 percent probability that 75 percent or more of the foliage would have been retained naturally at populations up to 30+ larvae per 45-cm branch tip.

As previously mentioned, it was surmised that these observations were likely influenced by a combination of good shoot growth on trees and reduced budworm feeding intensity due to the cooler, wetter weather experienced in 1984 compared to 1983.

Estimates of Regional probabilities of obtaining desired levels of foliage retention were calculated. Differences were greatly influenced by sample size (i.e. number of plots falling within each larval density range) and sampling intensity (i.e. number of plots within each Region).

3.4 Foliage Retention Probabilities in Treated Plots

Using the 1984 expected probabilities for normal foliage retention in unsprayed conditions, comparisons with similar values from sprayed plots were made to investigate whether treatment effects were detectable in terms of increased probabilities of retaining specified foliage levels at varying population densities.

Figures 10 and 11 illustrate results obtained on balsam fir in TBM and small aircraft spray blocks according to the treatments each received. Two levels of foliage retention were examined, viz. the stated objective level of 60 percent or more, and a

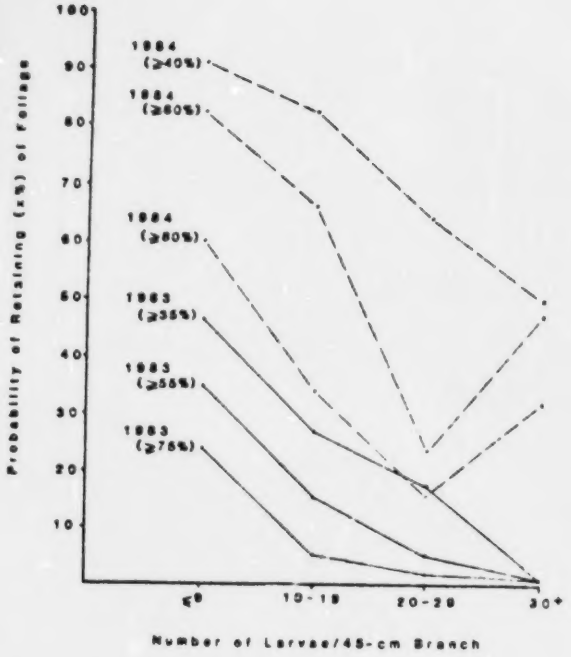

FIGURE 8. Comparison of 1983 and 1984 probabilities of retaining selected amounts of current year's foliage on balsam fir in untreated plots.

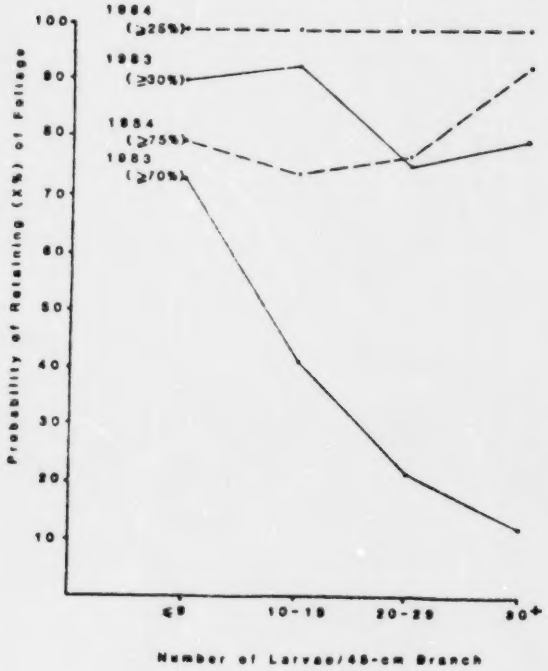

FIGURE 9. Comparison of 1983 and 1984 probabilities of retaining selected amounts of current year's foliage on red-black spruce in untreated plots.

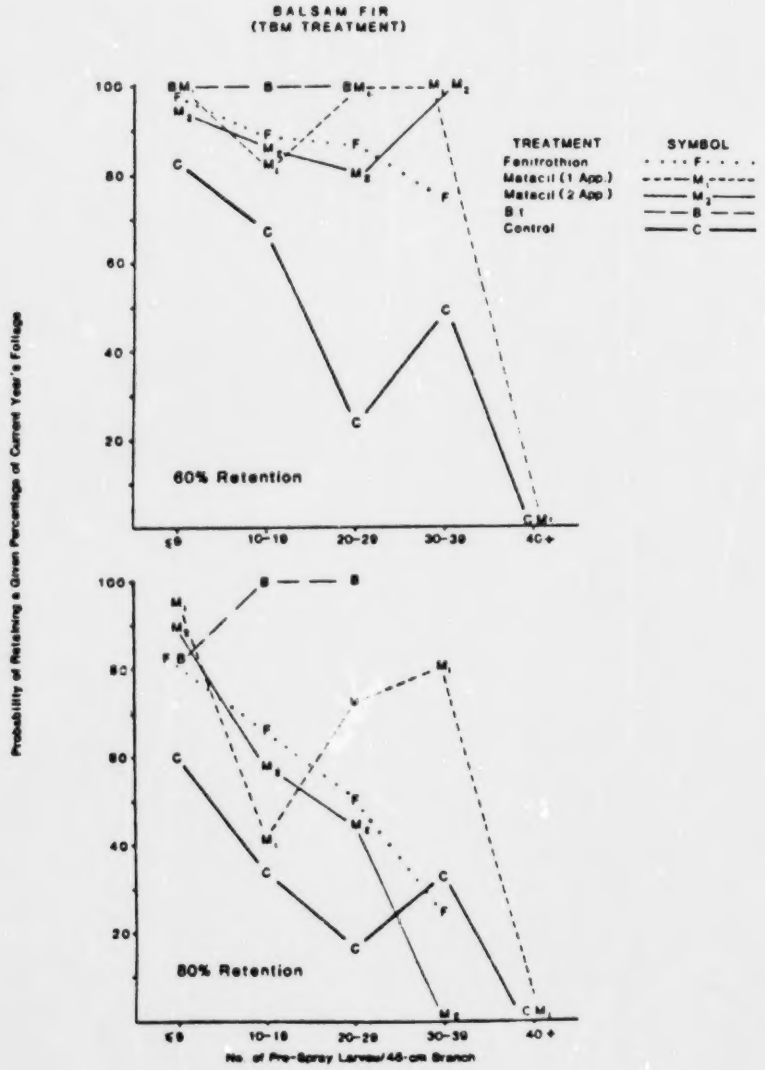

FIGURE 10. Comparison of the probabilities (by treatment) of retaining 60% or 80% of current year's foliage on balsam fir in untreated plots with plots from blocks treated by TBM aircraft in 1984.

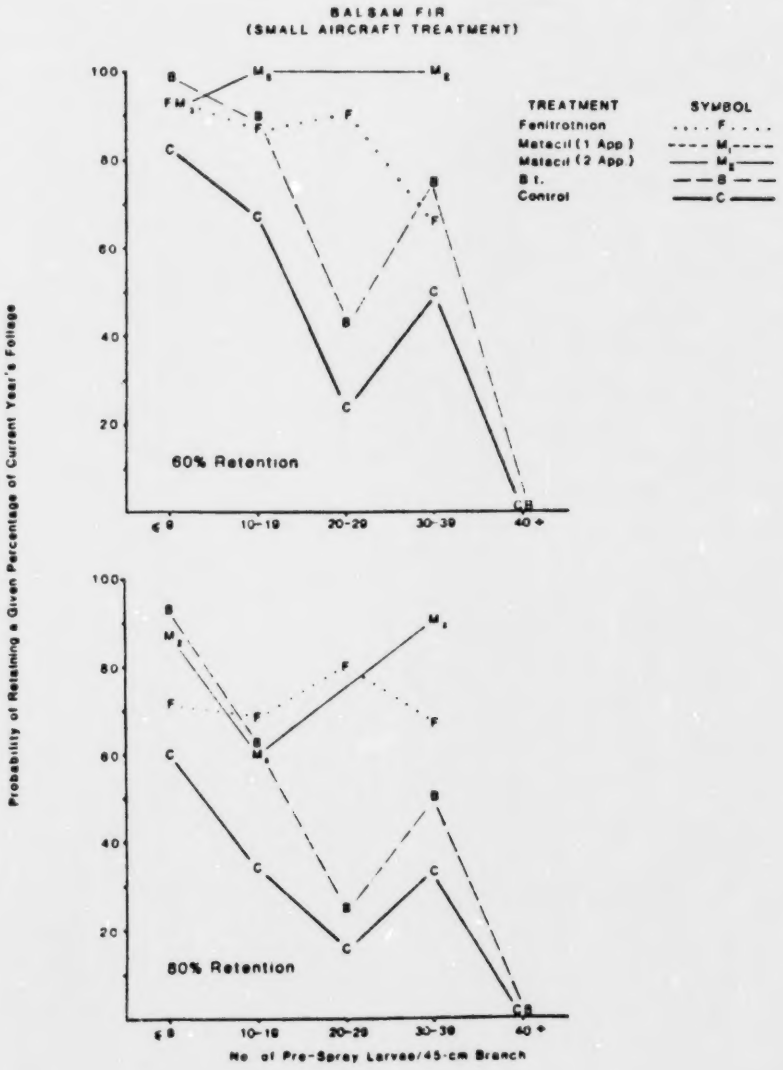

FIGURE 11. Comparison of the probabilities (by treatment) of retaining 60% or 80% of current year's foliage on balsam fir in untreated plots with plots from blocks treated by small aircraft in 1984.

higher objective of 80 percent or more. Benefits of treatment then became more evident as there were in fact significant increases in the probabilities of retaining 60 or 80 percent or more of the current year's foliage at different population levels with the different spray regimes that were applied. Keeping in mind the variable number of sample plots between treatments at each population density, no consistent differences between insecticides or single versus double applications were evident.

Figures 12 and 13 illustrate results obtained on red-black spruce in TBM and small aircraft spray blocks according to treatments each received. One can again see that for the objective level of 50 percent or more foliage retention there was a 95 to 100 percent probability of this happening or being achieved regardless of treatment even at the highest population densities noted in 1984. Spray benefits at this level were therefore marginal if any, in 1984. If, however, the level of foliage retention was raised to 75 percent or more, then differences and hence the benefits of treatment became evident. Curiously, the double application of Matacil in the industrial program did not appear to produce results as good as those seen for the other insecticides on red-black spruce. On the other hand, the double Matacil treatments applied by small aircraft appeared to give the best results. Reasons for these anomalies are not known, but it may be that sampling intensity at the various population ranges might be partly responsible.

3.5 Defoliation vs Larval Density - Treatment Effects

The preceding sections examined the probabilities of retaining specified levels of foliage on infested trees in untreated areas (Section 3.3) and compared these probabilities to those obtained from treated areas (Section 3.4). This section examines defoliation levels as a function of pre-spray larval density and compares results between untreated and treated plots by spray aircraft type and treatment applied.

Figure 14 illustrates average percent defoliation levels on balsam fir from all untreated and treated plots. This figure shows that mean defoliation levels at all population densities were lower in treated plots than in untreated plots regardless of aircraft type or treatment. Nevertheless, analyses revealed that these means were not significantly different between treatments, or between treatments versus check areas. Similarly, no significant differences could be detected for red-black spruce (Figure 15). Regional trends were also examined but with the same general conclusions. Again it was reasoned that weather and less intensive feeding largely influenced these results.

3.6 Weather Observations

The influence of weather has been referred to in several preceding sections. Figure 2 illustrated the rate of accumulation of degree days in 1984 compared with similar rates for the pre-

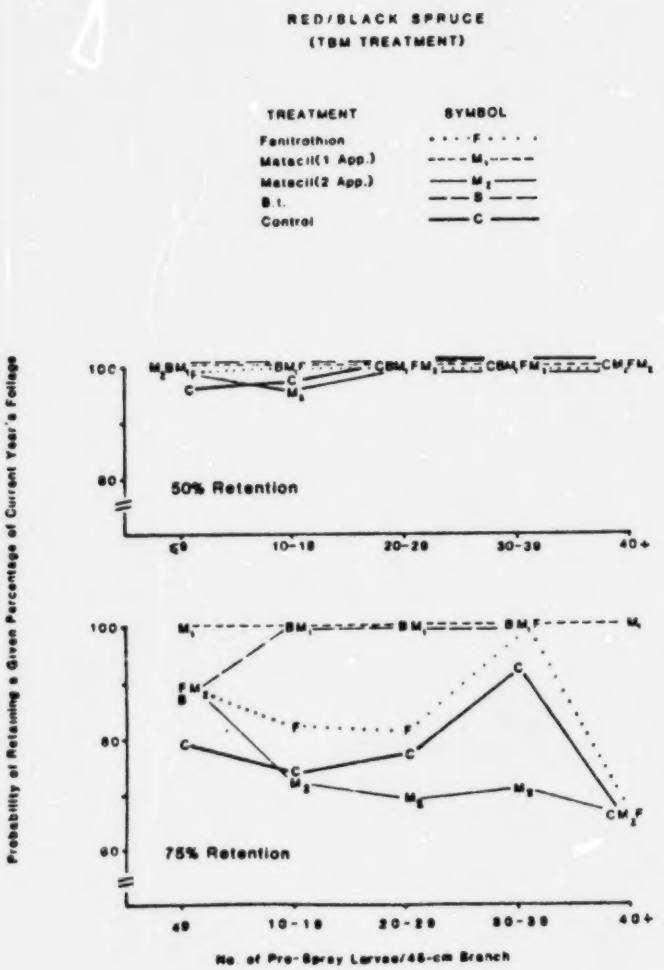

FIGURE 12. Comparison of the probabilities (by treatment) of retaining 50% or 75% of current year's foliage on red-black spruce in untreated plots with plots from blocks treated by IBM aircraft in 1984.

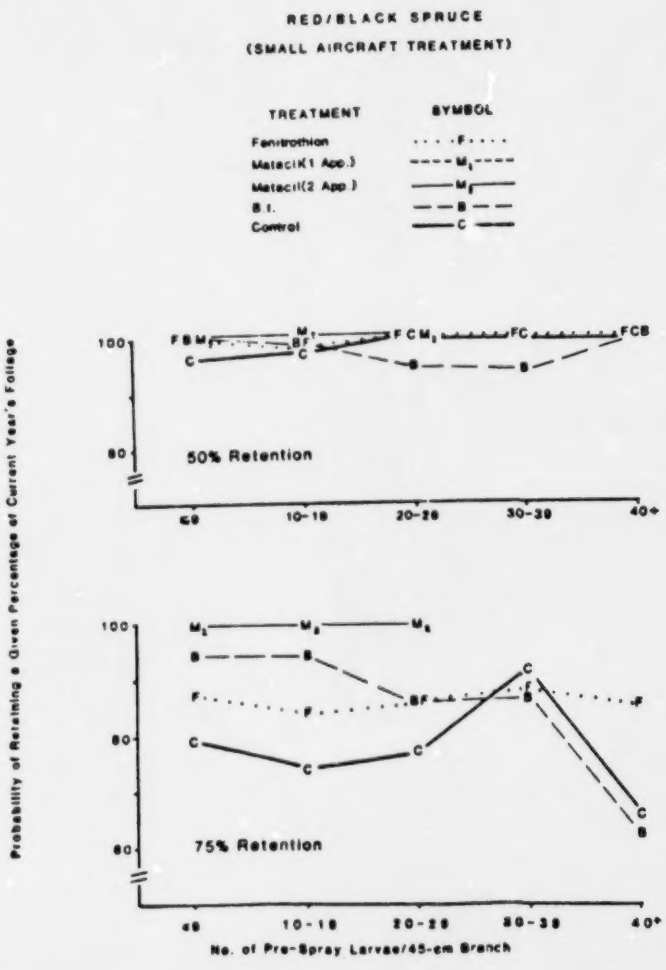

FIGURE 13. Comparison of the probabilities (by treatment) of retaining 50% or 75% of current year's foliage on red-black spruce in untreated plots with plots from blocks treated by small spray aircraft in 1984.

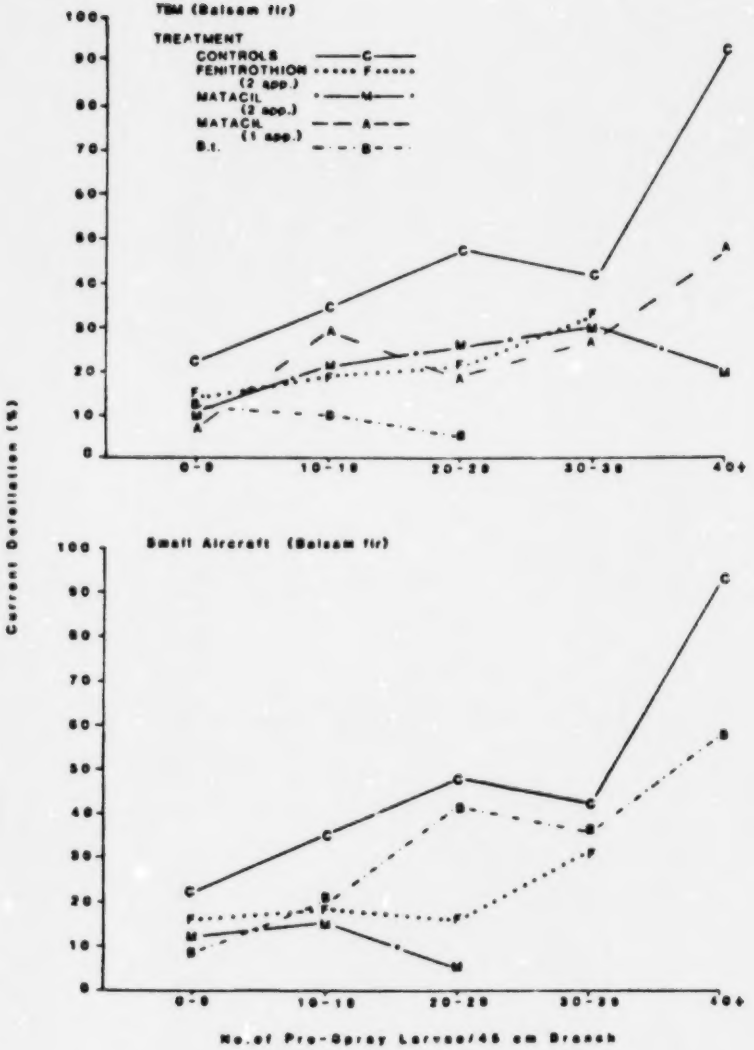

Figure 14. Current defoliation on balsam fir in untreated and treated plots (by treatment) based on prespray larval density ranges.

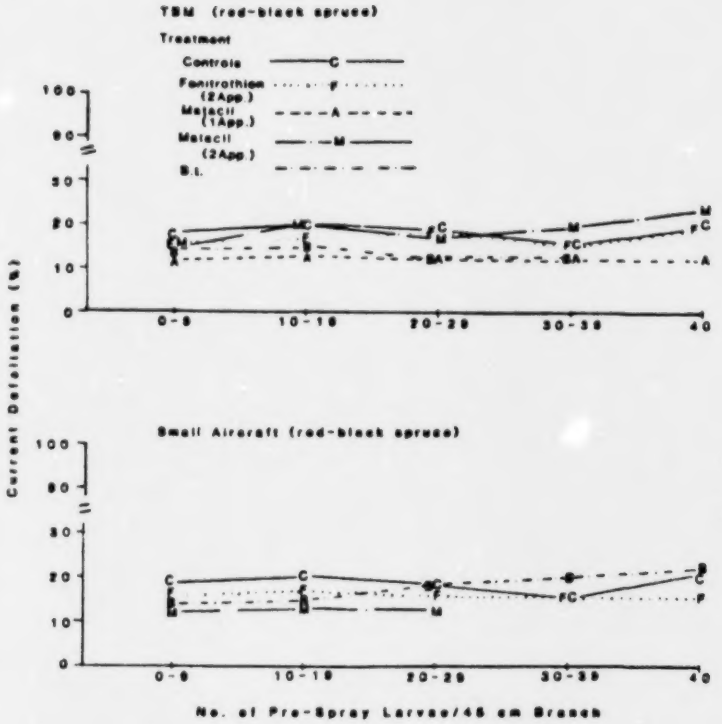

Figure 15. Current defoliation on red-black spruce in untreated and treated plots (by treatment) based on prespray larval density ranges.

vious 5 years. The cool spring was responsible for the later-than-normal commencement of spray operations in 1984. By the first week of June, however, degree days had reached "average" levels.

According to Varty and Godin (1983), cold or wet weather may depress larval activity and reduce the vulnerability of the insects to the spray. Presumably such conditions also limit larval feeding. Consequently, rainfall data for 1983 and 1984 were examined for the period during which budworm were in the fifth and sixth instars, the main feeding stages. These stages lasted from about June 15 to July 10 in both years.

Figure 16 illustrates the average quantity of rain and average number of days that rain was recorded for the specified period at several weather stations located within each Region in 1983 and 1984. Rainfall was 1.5 to 3.2 times as great in 1984 as in 1983. Similarly, rain was recorded on twice as many days in 1984 as in 1983. If the hypothesis of Varty and Godin (1983) is correct, then weather could have been a very significant reason why the benefits of the 1984 spray program were difficult to determine and also why they contrast greatly with 1983 - given also the nature and variability of operationally collected data as opposed to intensive sampling within an experimental program.

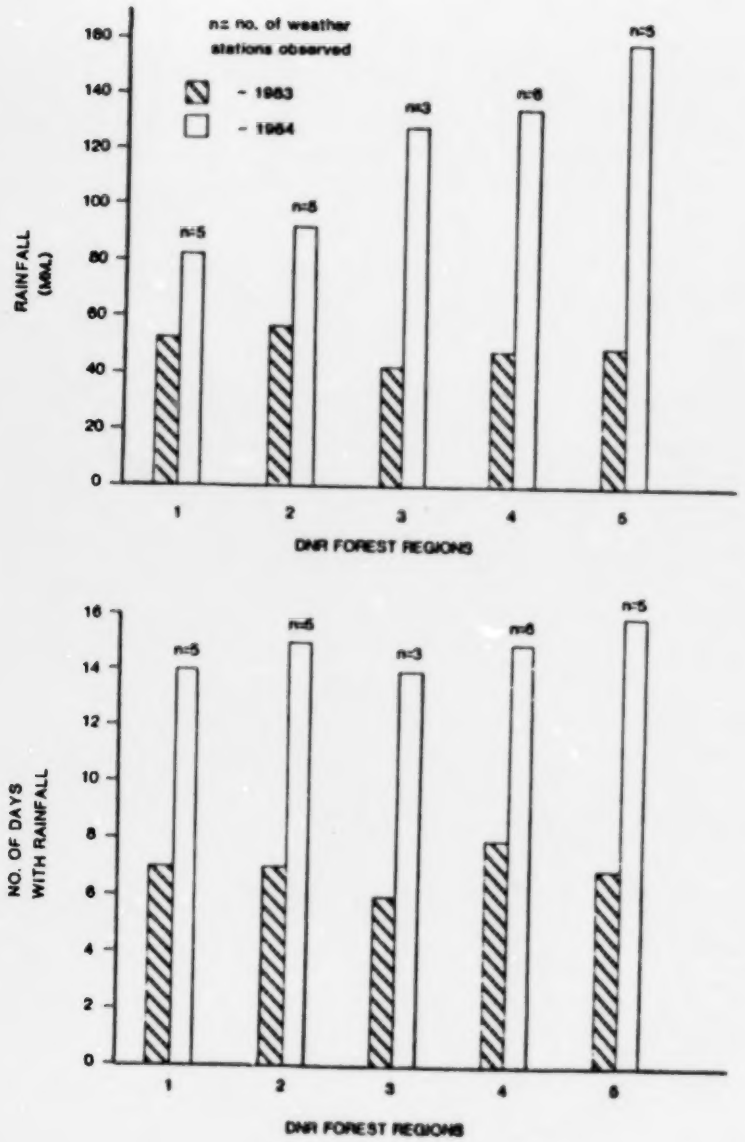

Figure 16. Total rainfall (mm) and number of days with rainfall between June 15 and July 10 in 1983 and 1984 within the DNR Administrative Regions.

4. INFESTATION AND HAZARD FORECAST FOR 1985

The 1984 spruce budworm egg mass survey was conducted at 1476 locations distributed throughout the susceptible forests of the Province. This sampling intensity represented about one plot for every 2600 ha of susceptible forest and was the most intensive survey of this type conducted east of Ontario and the State of Maine. Analysis of the data revealed no significant change in the proportion of sample points falling within the same categories as in 1983 (Table 10). Based on these samples, a forecast map of moderate to high population levels (Figure 17) was constructed revealing continued outbreak infestation conditions throughout approximately 3.57 million ha of forest area in 1985. This appears to be slightly down from similar forecasts of 4.10 and 5.30 million ha in 1983 and 1982, respectively but in fact there may only be a slight difference from 1983 due to the interpretive methods used to derive these maps.

Hazard values, representing tree condition and spruce budworm threat to the forest (Dorais and Kettela, 1982), were also calculated for each of the egg mass sample points. Examination of these data revealed a general overall improvement in forest conditions in 1984 as expressed by a 17 percent reduction in the proportion of points in the combined moderate, high, and extreme categories (Table 10). This optimistic situation is attributed largely to an improvement in tree vigor, as expressed by low levels of defoliation and excellent shoot growth on softwood trees during 1984.

Table 10. Comparison of 1983 and 1984 spruce budworm egg mass densities and forest hazard ratings.

FORECAST INFESTATION LEVEL

Category:	Low	Moderate	High	
(egg mass/10 m^2)	(0-99)	(100-239)	(240+)	
1983	639	257	423	n=1316
	(48%)	(20%)	(32%)	
1984	747	331	398	n=1476
	(51%)	(22%)	(27%)	

FORECAST HAZARD LEVELS

Category:	Low	Moderate	High	Extreme	
(range)	(0-7)	(8-10)	(11-14)	(15+)	
1983	790	261	201	64	n=1316
	(60%)	(20%)	(15%)	(5%)	
1984	1133	231	89	23	n=1476
	(77%)	(16%)	(6%)	(1%)	

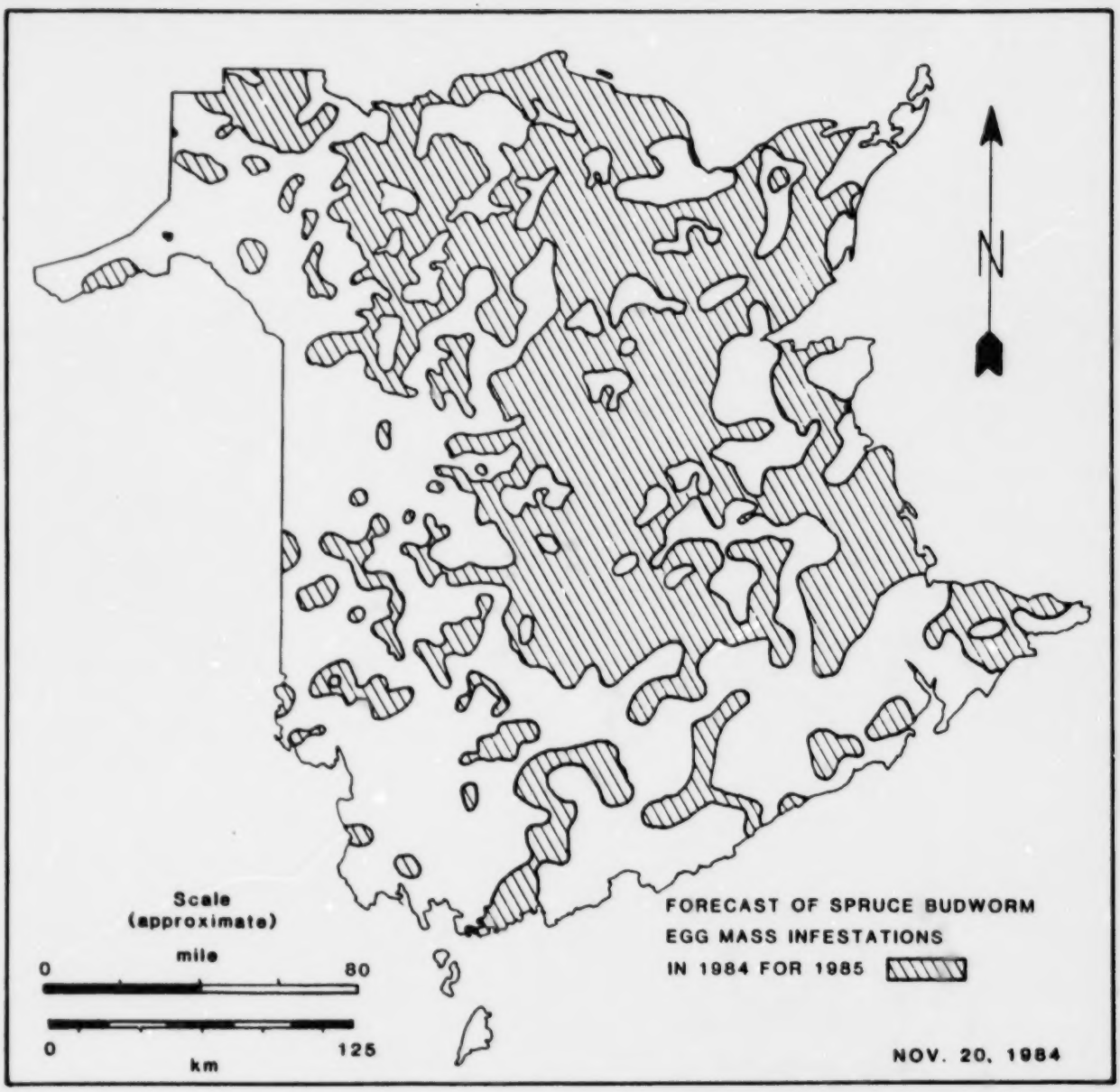

Figure 17. Map illustrating the forecast area of moderate to severe spruce budworm infestation for 1985 in New Brunswick (based on 100+ egg masses per $10m^2$ foliage).

5. CONCLUSIONS

5.1 Spraying Operations

1. Spray applications were applied within the conventional time period for larval spraying. Intervals between chemical treatments were more protracted in the small aircraft operation than in the TBM operation. The single B.t. treatments were likewise protracted in the small aircraft operation.

2. The spray timing zones and biological criteria used in 1984 appeared adequate to determine when spray blocks were "open" for initial spray applications according to current practices.

5.2 Effectiveness of Program

1. Provincially, foliage preservation in the great majority of sprayed blocks met the program's objectives of retaining 60 percent or more of the current year's foliage on balsam fir and 50 percent or more on red-black spruce.

2. The majority of plots (90+ percent) met program objectives for foliage protection on balsam fir and red-black spruce, though there were some cases where defoliation did exceed desired limits. In many unsprayed check plots (75 percent of balsam fir and 98 percent of red-black spruce) defoliation levels were also within acceptable limits thereby masking the benefits of treatment.

3. Pre-spray population checks revealed variable larval densities with most populations ranging from 0 to 19 larvae per 45-cm branch tip, both in untreated areas and spray blocks.

4. In 1984, compared to 1983, there were higher probabilities of retaining specified levels of foliage in the absence of spraying on both balsam fir and red-black spruce. When similar "probability" data from sprayed plots were compared to unsprayed plots, there were higher probabilities of attaining stated foliage retention levels in treated plots thereby revealing the benefits of treatment. No consistent differences, however, between treatments could be established due to inconsistent numbers of plots at each larval density range.

5. Mean defoliation levels for balsam fir were lower at all population levels in treated plots than in untreated plots regardless of aircraft type or treatment though differences were not significant between treatments (including controls).

6. Likewise, mean defoliation levels between treatments on red-black spruce were not significantly different.

7. Natural budworm survival to the pupal stage in unsprayed plots varied with early larval densities and ranged from 8 to 44 percent on balsam fir and from 5 to 25 percent on red-black spruce.

8. Weather observations from around the Province indicated greater rainfall and more rainy days during the period of late-larval instars in 1984 compared to 1983. This weather probably influenced the results of the 1984 spray program by promoting good shoot growth on host trees and by inhibiting budworm feeding, thereby masking the benefits of treatment.

9. Results from aerial and ground surveys of defoliation indicated about 0.73 million ha of moderate and severe defoliation scattered throughout the Province in 1984.

5.3 Forecast

1. The 1984 egg mass survey indicated continued outbreak conditions over some 3.57 million ha in 1985.

2. Calculation of hazard values representing tree condition and potential budworm threat revealed an overall improvement in conditions as expressed by a 17 percent reduction from 1983 in the proportion of sample points in the combined moderate, high, and extreme categories. This reflected extensive areas with low levels of defoliation, excellent shoot growth, and recovery during the summer of 1984.

6. RECOMMENDATIONS

1. It is anticipated that there will be an increase in the proportion of future spray programs that will be treated with small spray planes rather than TBM aircraft. Increasing the numbers of "small blocks" will create a more logistically complicated program. In light of the more protracted time taken in the "small aircraft" part of the 1984 operation, it is essential that the main operator, Forest Protection Ltd., assemble sufficient number of aircraft and maintain a strong control over aircraft logistics to be as flexible as situations warrant.

2. The biological and phenological criteria used to "time" the 1984 spray program appeared to be acceptable according to current practices. These criteria should therefore be adopted until research into the "biological interface" provides practical guidelines that can refine and improve this aspect of the spray program.

3. The 1984 defoliation survey integrated information from ground and aerial surveys. Nevertheless, there appeared to be an east-west striped appearance on the resulting map which was probably largely attributed to the aerial survey. It is recommended that efforts be made to fly narrower swaths in the future and that ground surveys be conducted to augment aerial observations whenever necessary.

4. The goals of protection spray programs against budworm are long-term, however it is necessary to have some means of assessing the effectiveness of the program on an annual basis. At present, spray programs are considered successful if 60 percent of the current year's foliage is retained on balsam fir and 50 percent is retained on red-black spruce. It is recognized that the actual amount of foliage required to keep a tree alive and growing depends on many factors. For example, the amount of current year's foliage required to keep mature and overmature trees alive is different from that required to maximize the volume increment on young trees. Research is continuing to more precisely define foliage protection targets to be used in evaluating programs on an annual basis. In the meantime, continued use of the current 60 and 50 percent foliage retention targets is recommended.

5. In recognition of the differences between host species and the existing limitations of assessing percent current year's defoliation on red-black spruce, it is recommended that a more appropriate defoliation rating system be investigated as a replacement commencing in 1985.

6. Forecasting spruce budworm population levels has historically been done using egg mass data collected in August. Methods had been developed previously in New Brunswick to determine overwintering larval (or L2) populations and recent developments in Maine

and Quebec confirm that the method can be a cheaper and reliable alternative forecasting system. It is therefore recommended that the Department of Natural Resources consider replacing the traditional egg mass survey with a more intensive L2 survey within the next two years.

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APPENDIX

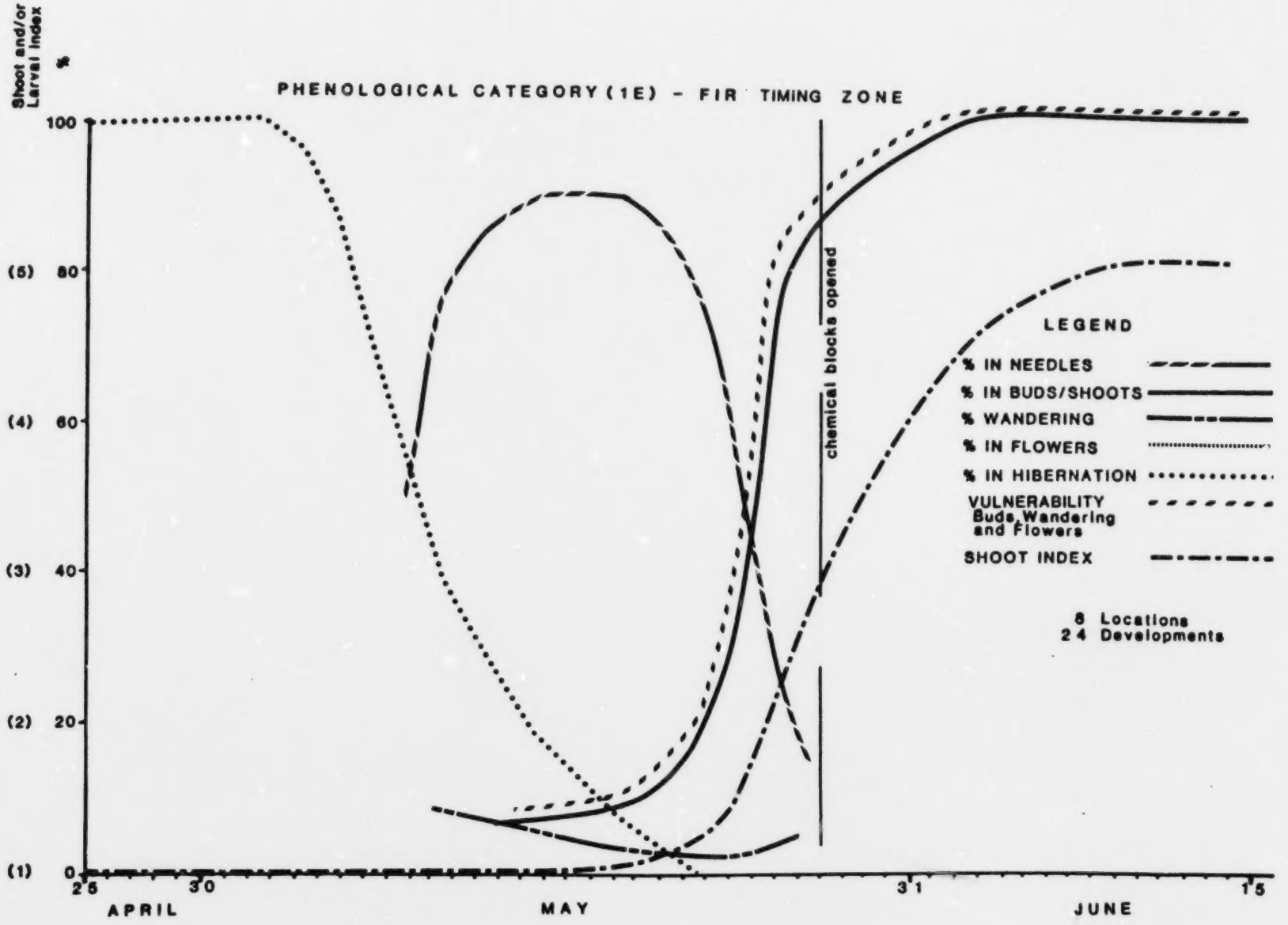

Figure A1. Relationships between larval behaviour and shoot development on balsam fir in phenological category 1E in the Fir Timed Zone in 1984.

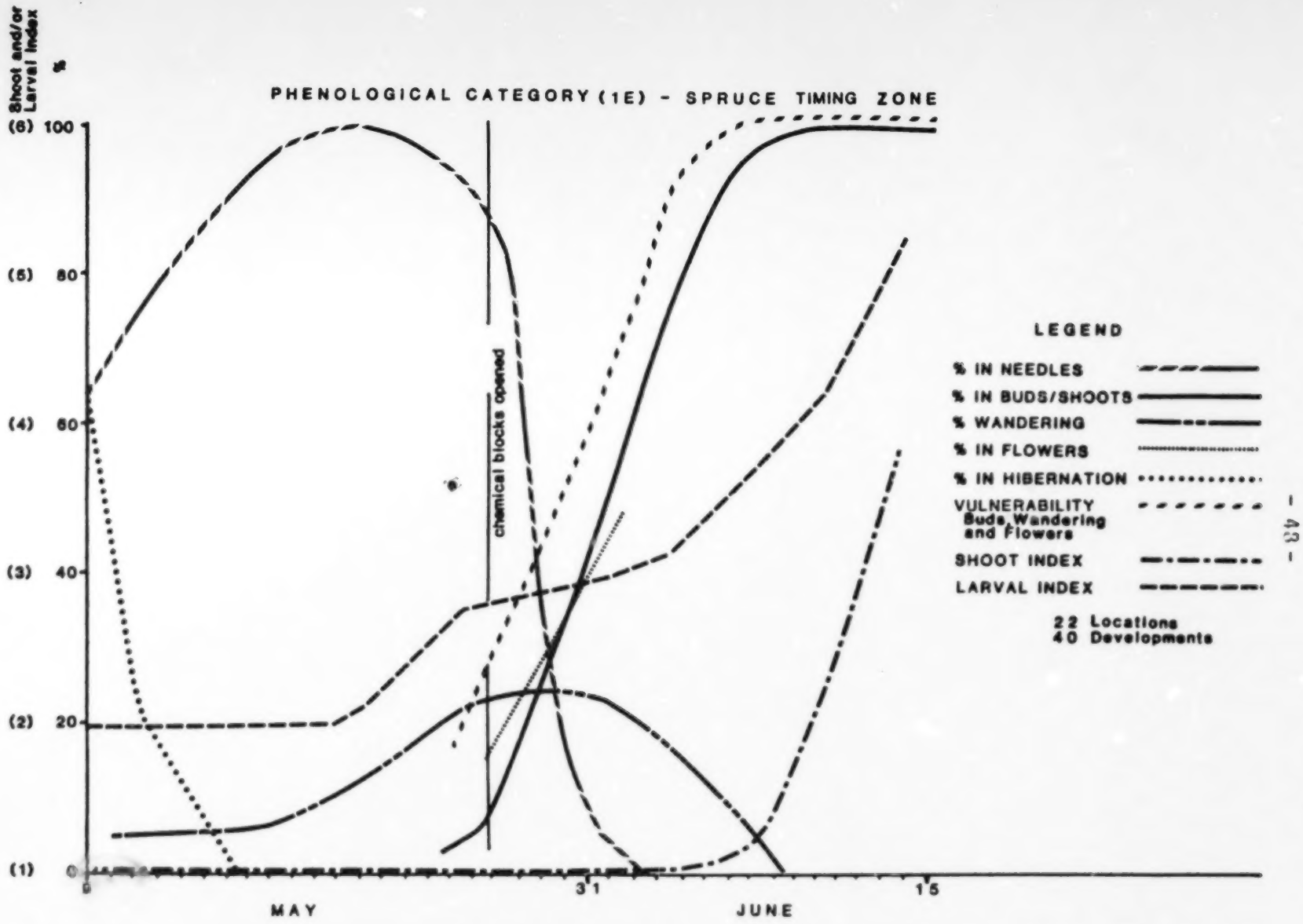

Figure A2. Relationships between larval development and behaviour, and shoot development on red-black spruce in phenological category 1E in the Spruce Timed Zone in 1984.

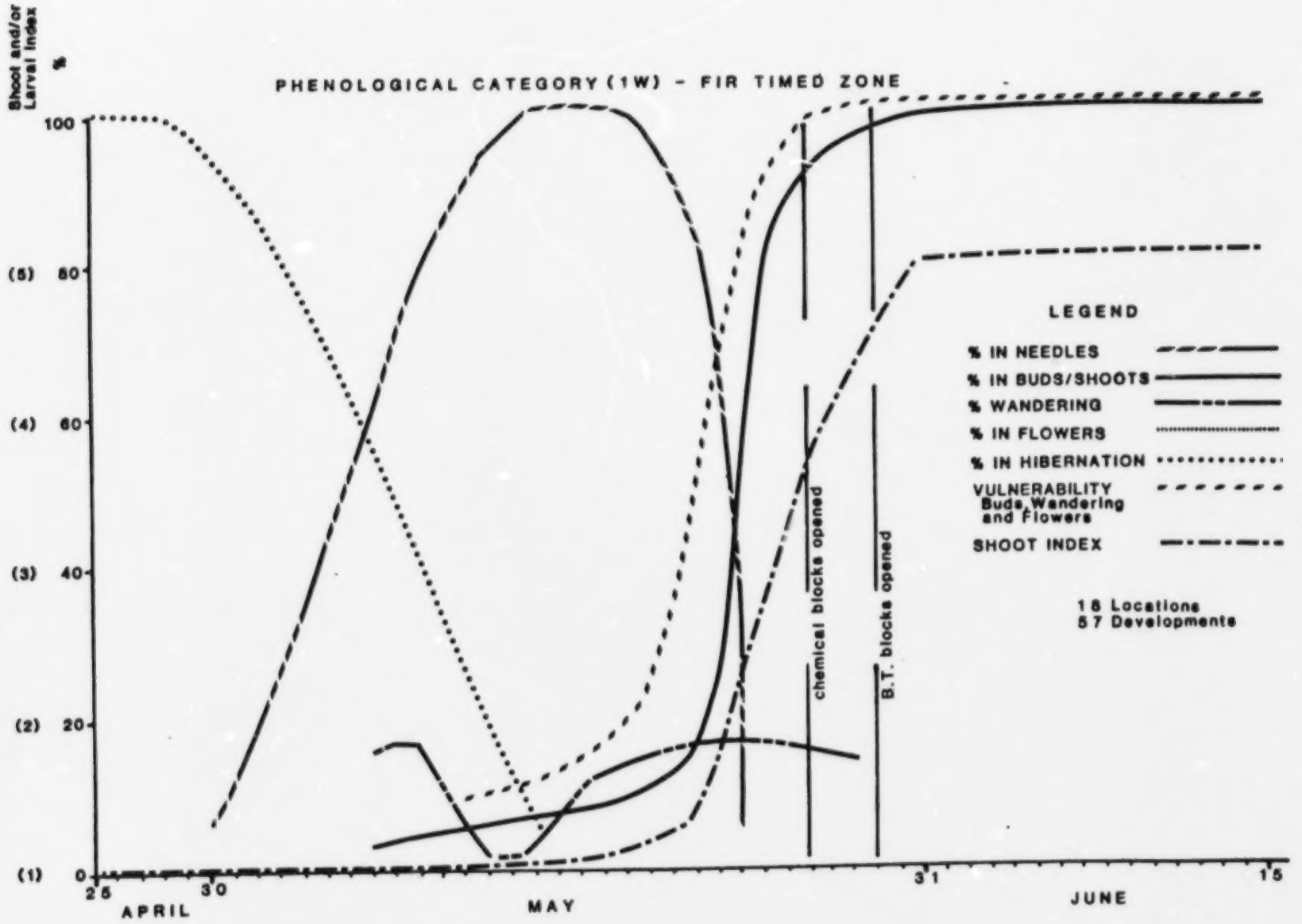

Figure A3. Relationships between larval behaviour and shoot development on balsam fir in phenological category 1W in the Fir Timed Zone in 1984.

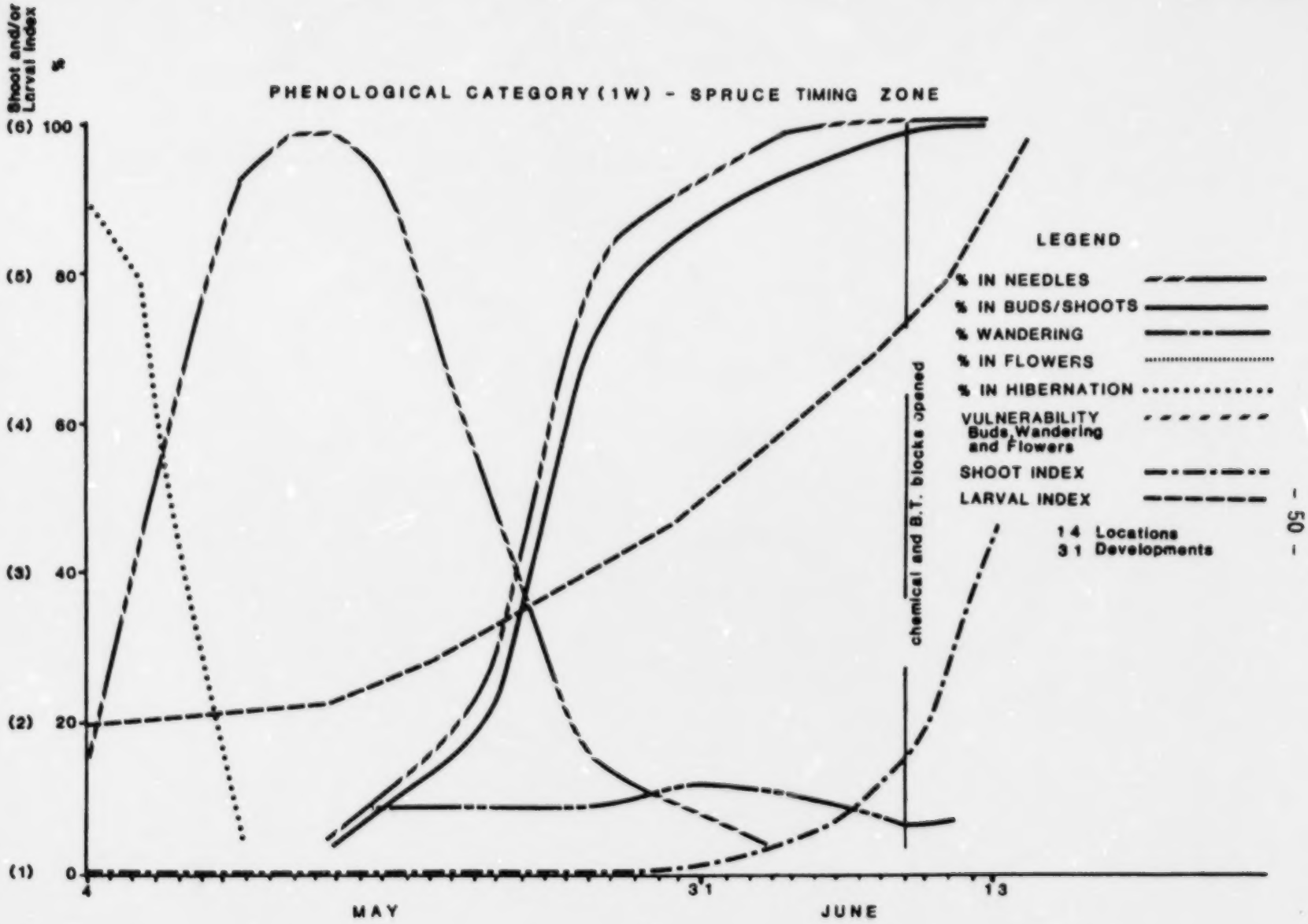

Figure A4. Relationships between larval development and behaviour, and shoot development on red-black spruce in phenological category 1W in the Spruce Timed Zone in 1984.

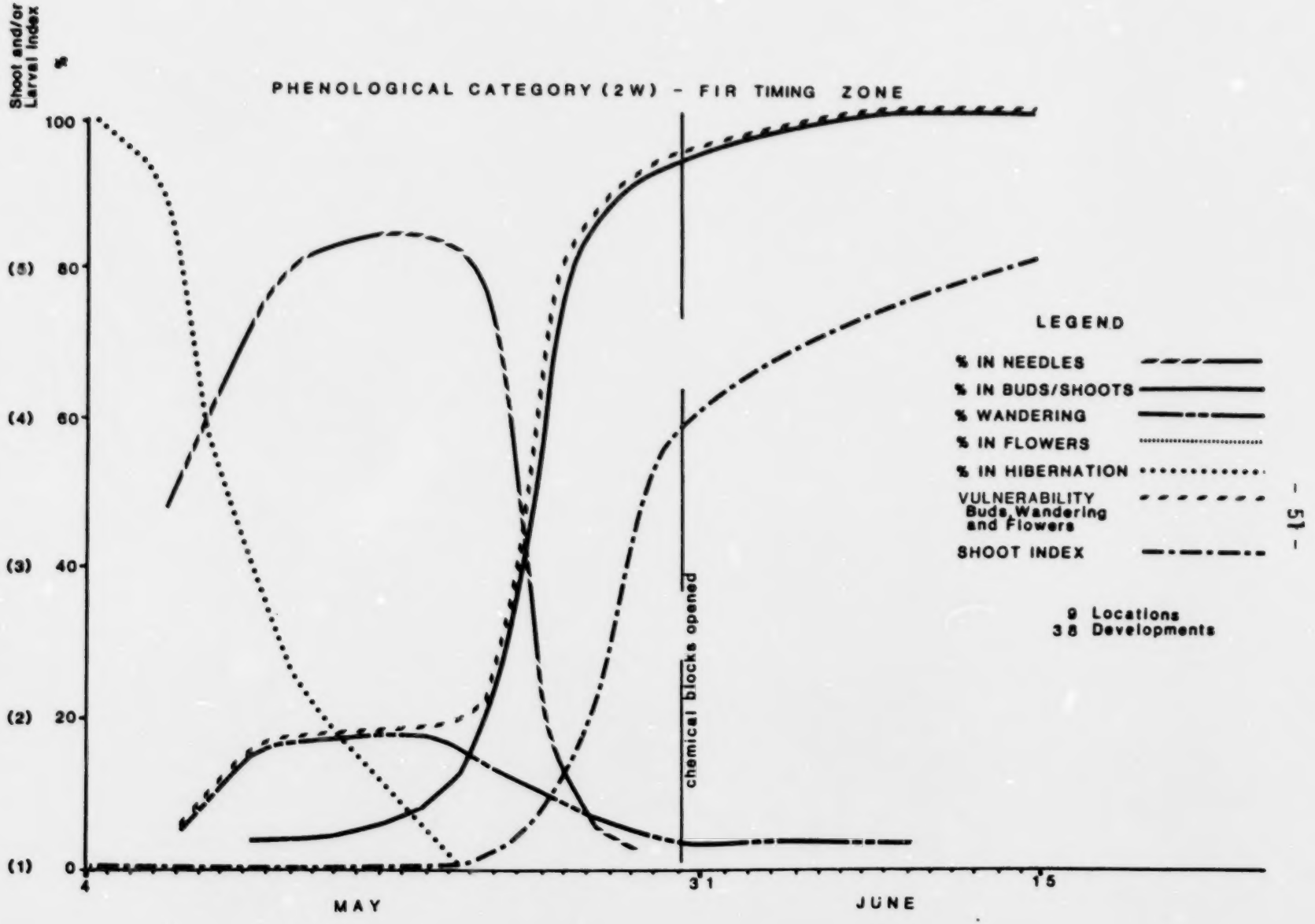

Figure A5. Relationships between larval behaviour and shoot development on balsam fir in phenological category 2W in the Fir Timed Zone in 1984.

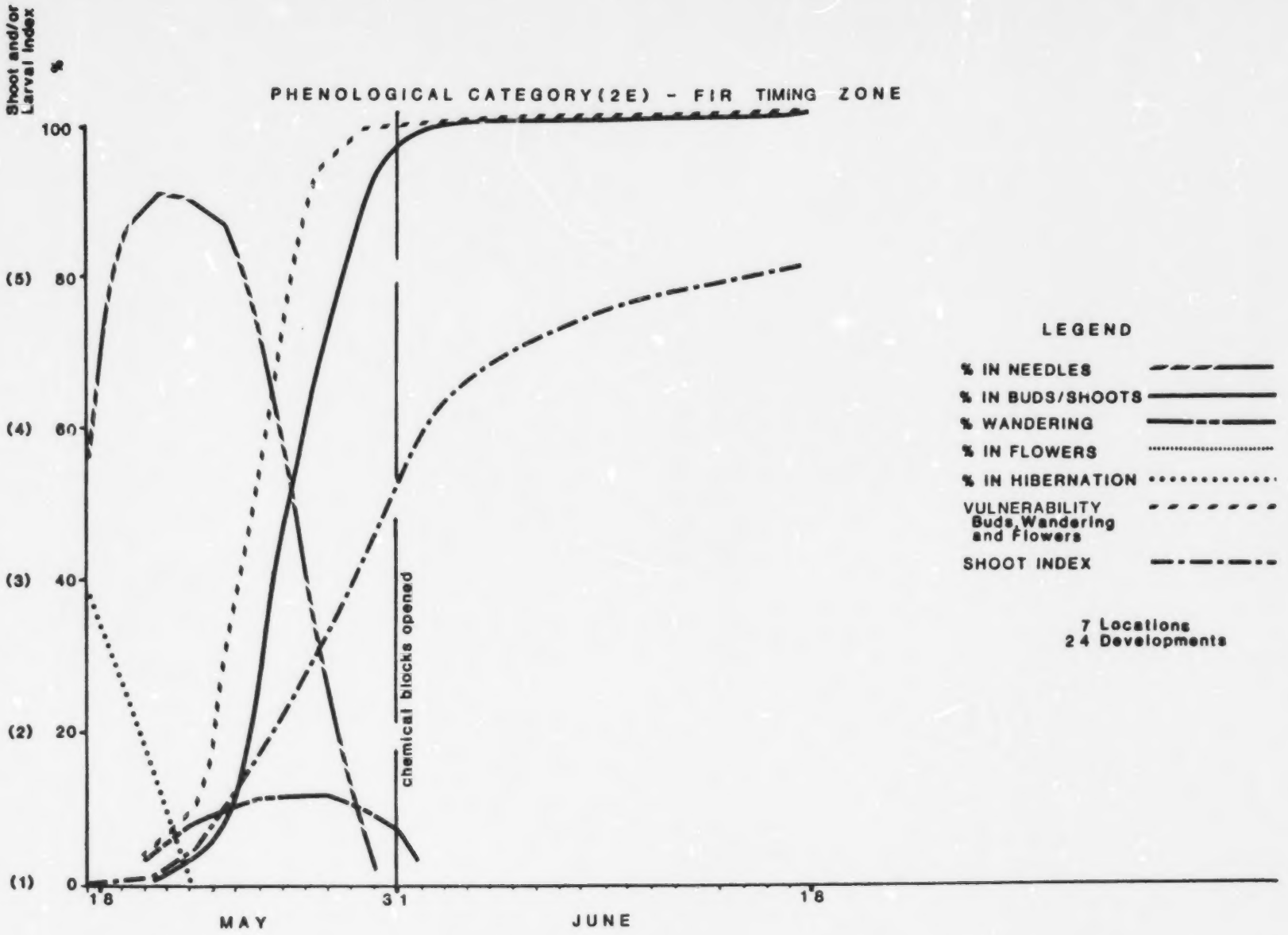

Figure A6. Relationships between larval behaviour and shoot development on balsam fir in phenological category 2E in the Fir Timed Zone in 1984.

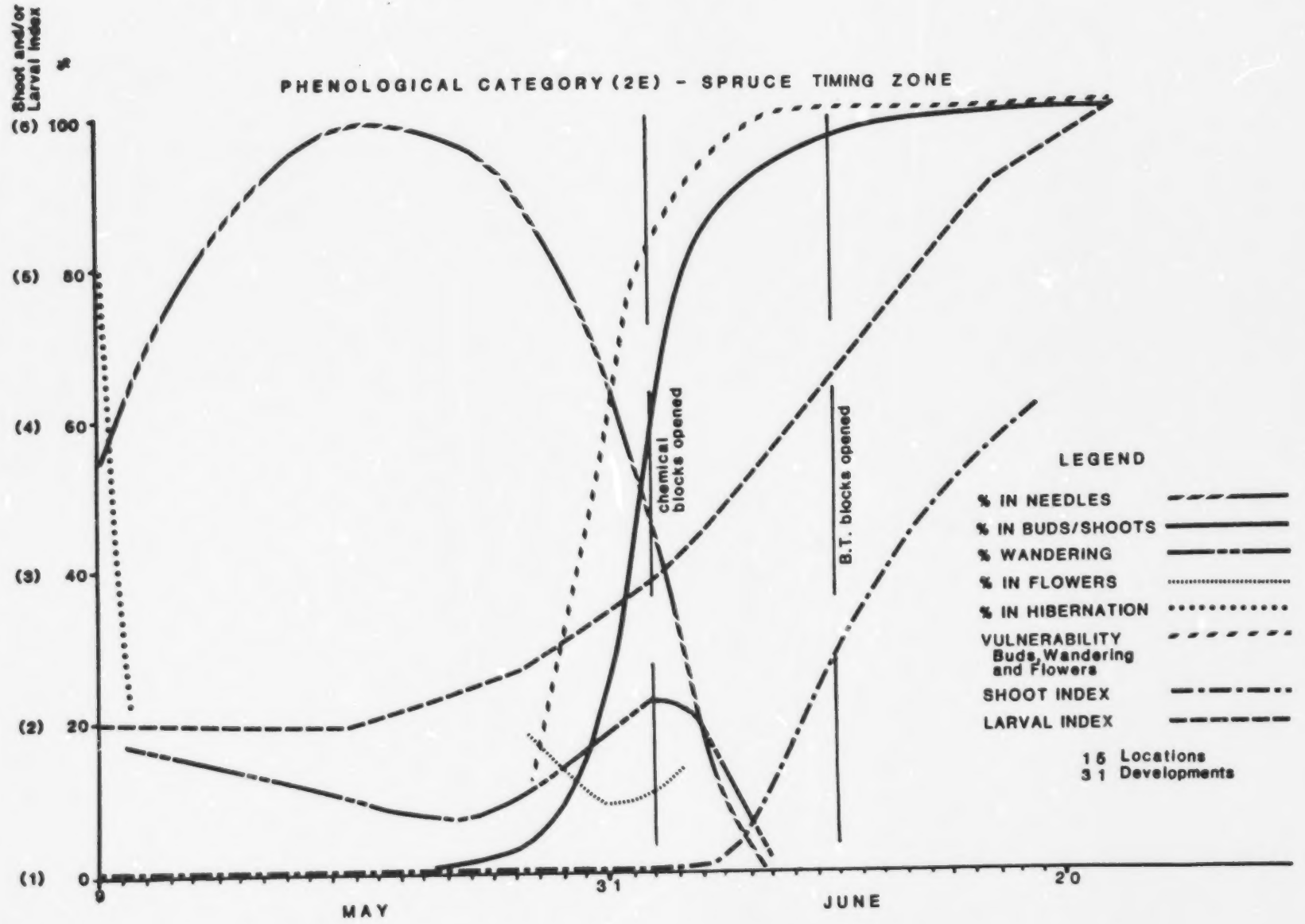

Figure A7. Relationships between larval development and behaviour, and shoot development on red-black spruce in phenological category 2E in the Spruce Timed Zone in 1984.

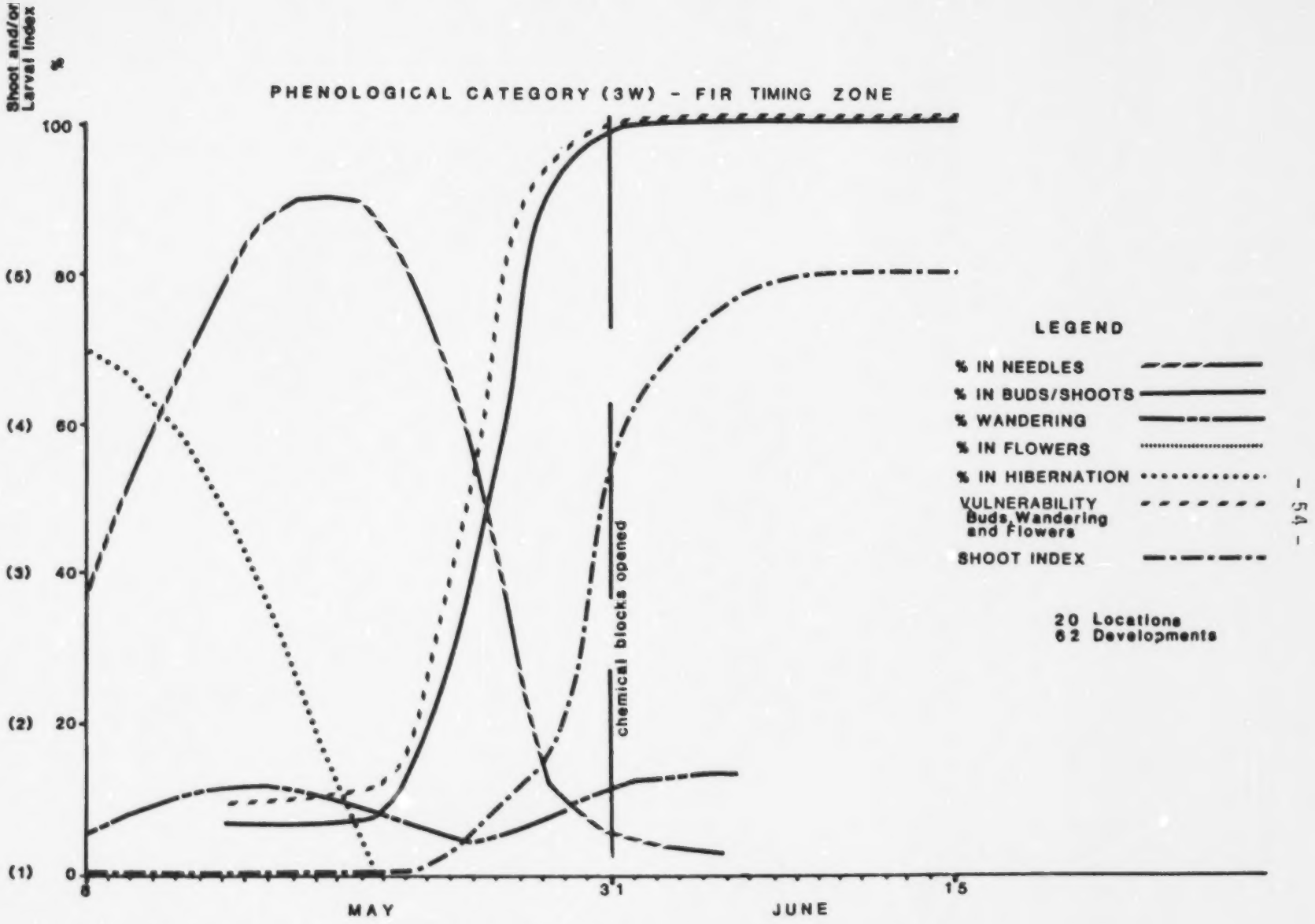

Figure A8. Relationships between larval behaviour and shoot development on balsam fir in phenological category 3W in the Fir Timed Zone in 1984.

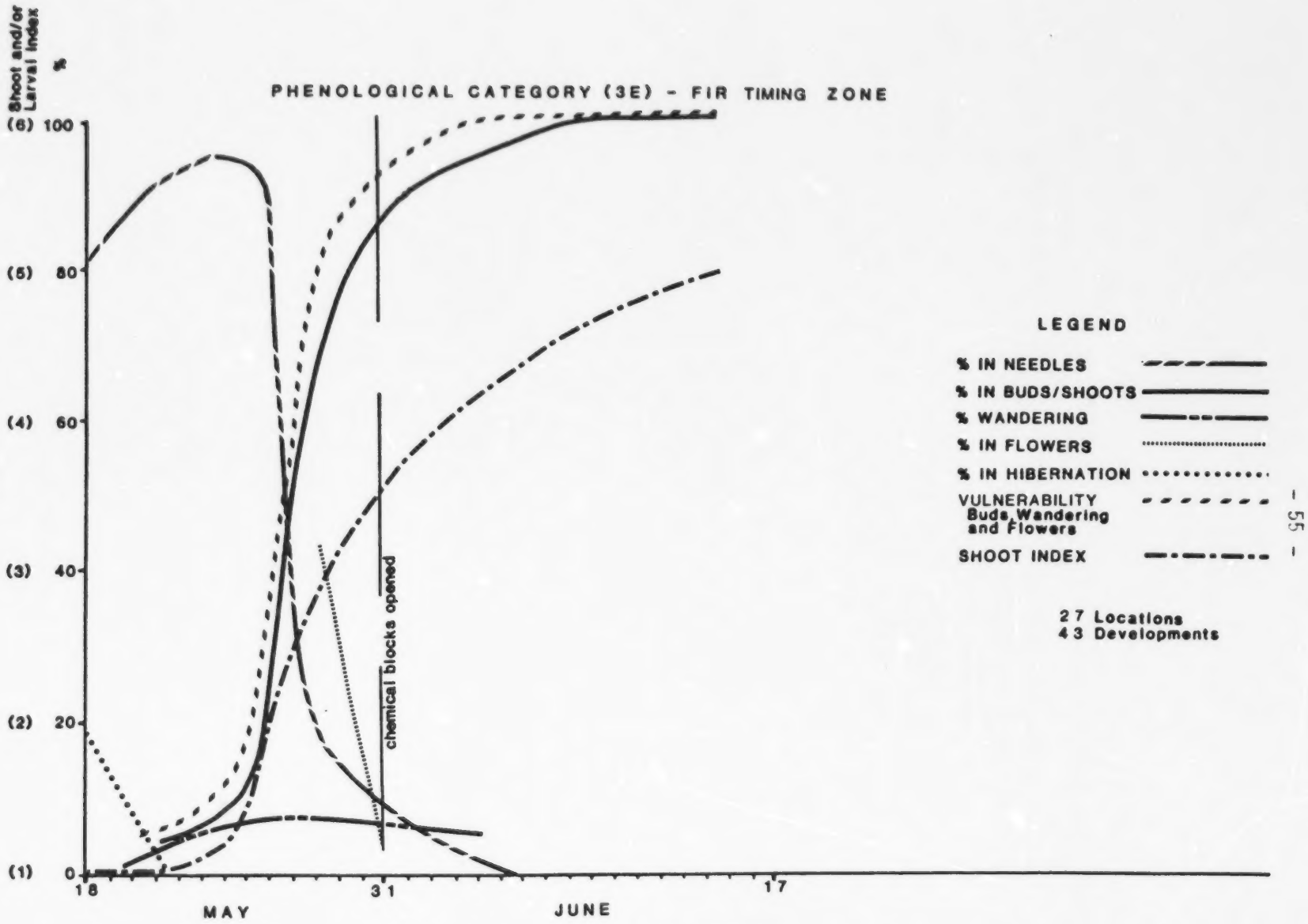

Figure A9. Relationships between larval behaviour and shoot development on balsam fir in phenological category 3E in the Fir Timed Zone in 1984.

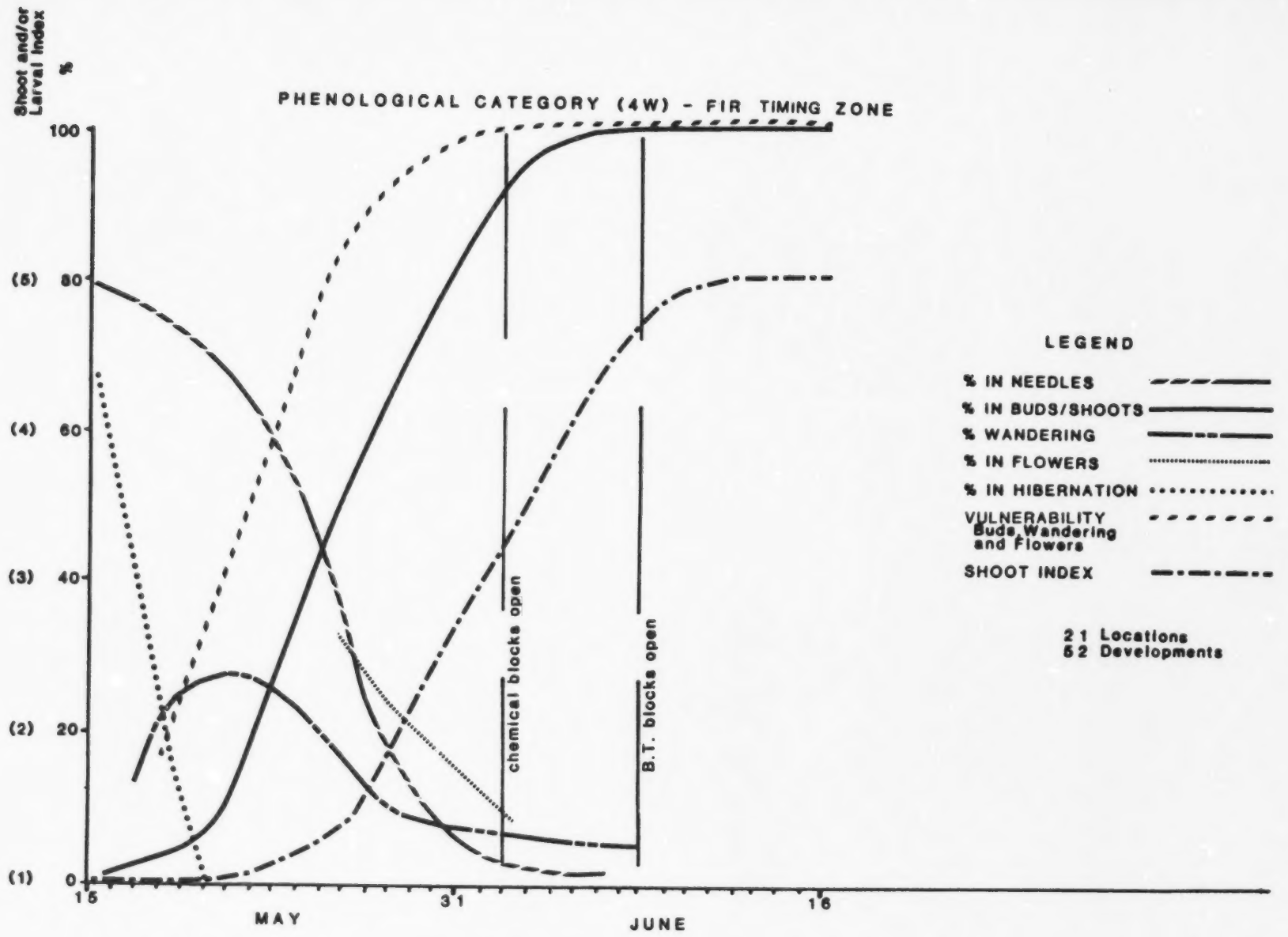

Figure A10. Relationships between larval behaviour and shoot development on balsam fir in phenological category 4W in the Fir Timed Zone in 1984.

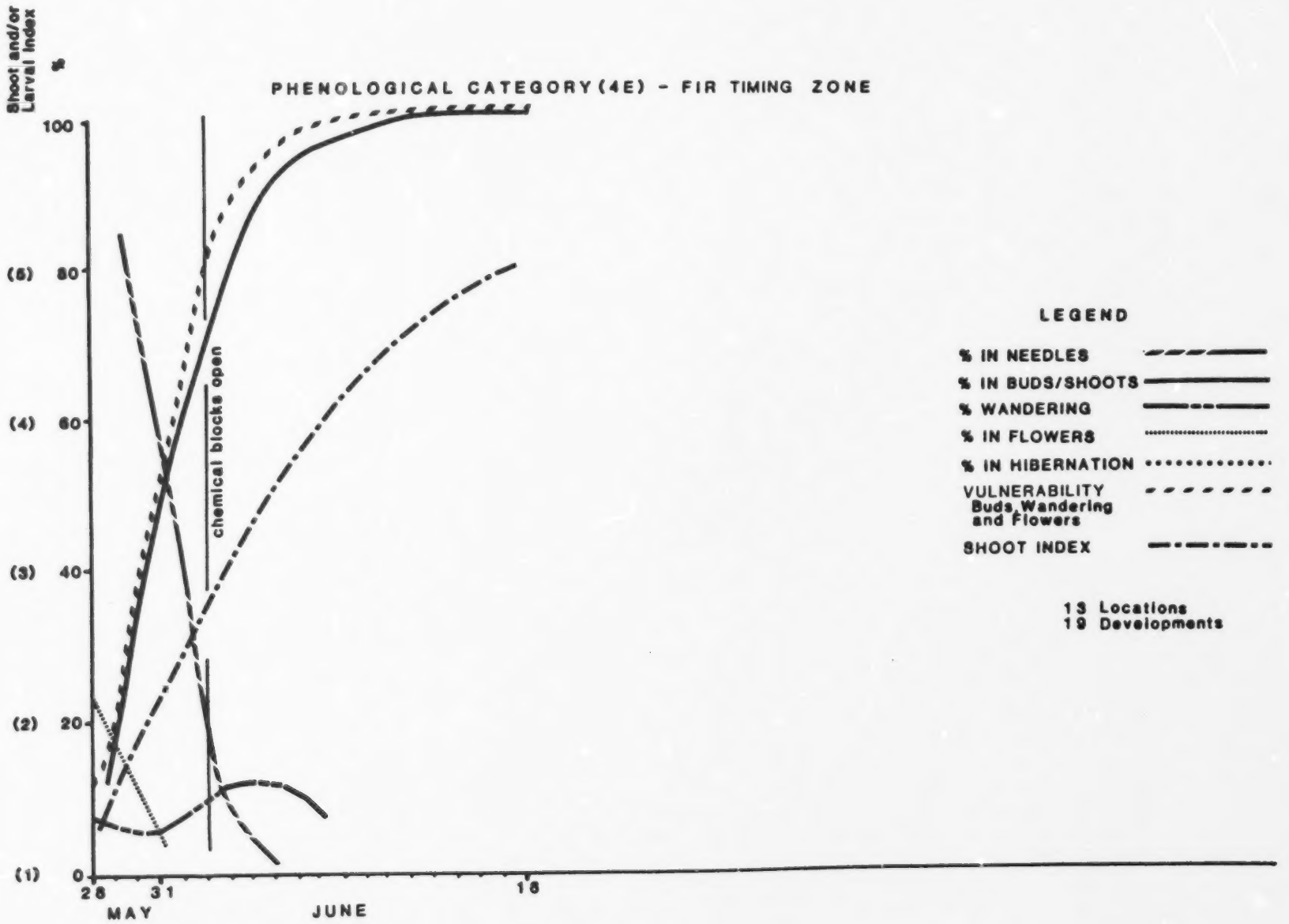

Figure A11. Relationships between larval behaviour and shoot development on balsam fir in phenological category 4E in the Fir Timed Zone in 1984.

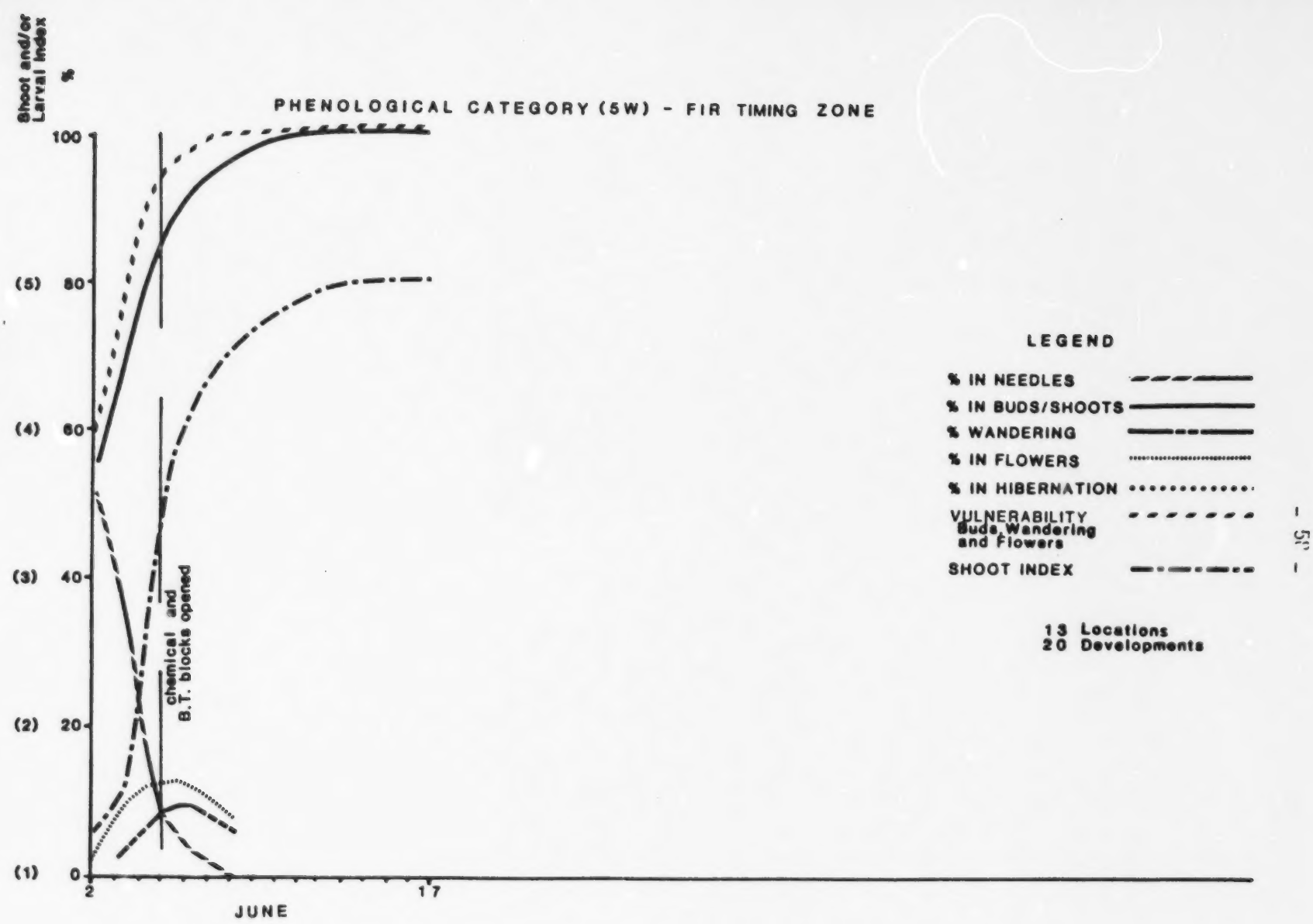

Figure A12. Relationships between larval behaviour and shoot development on balsam fir in phenological category 5W in the Fir Timed Zone in 1984.

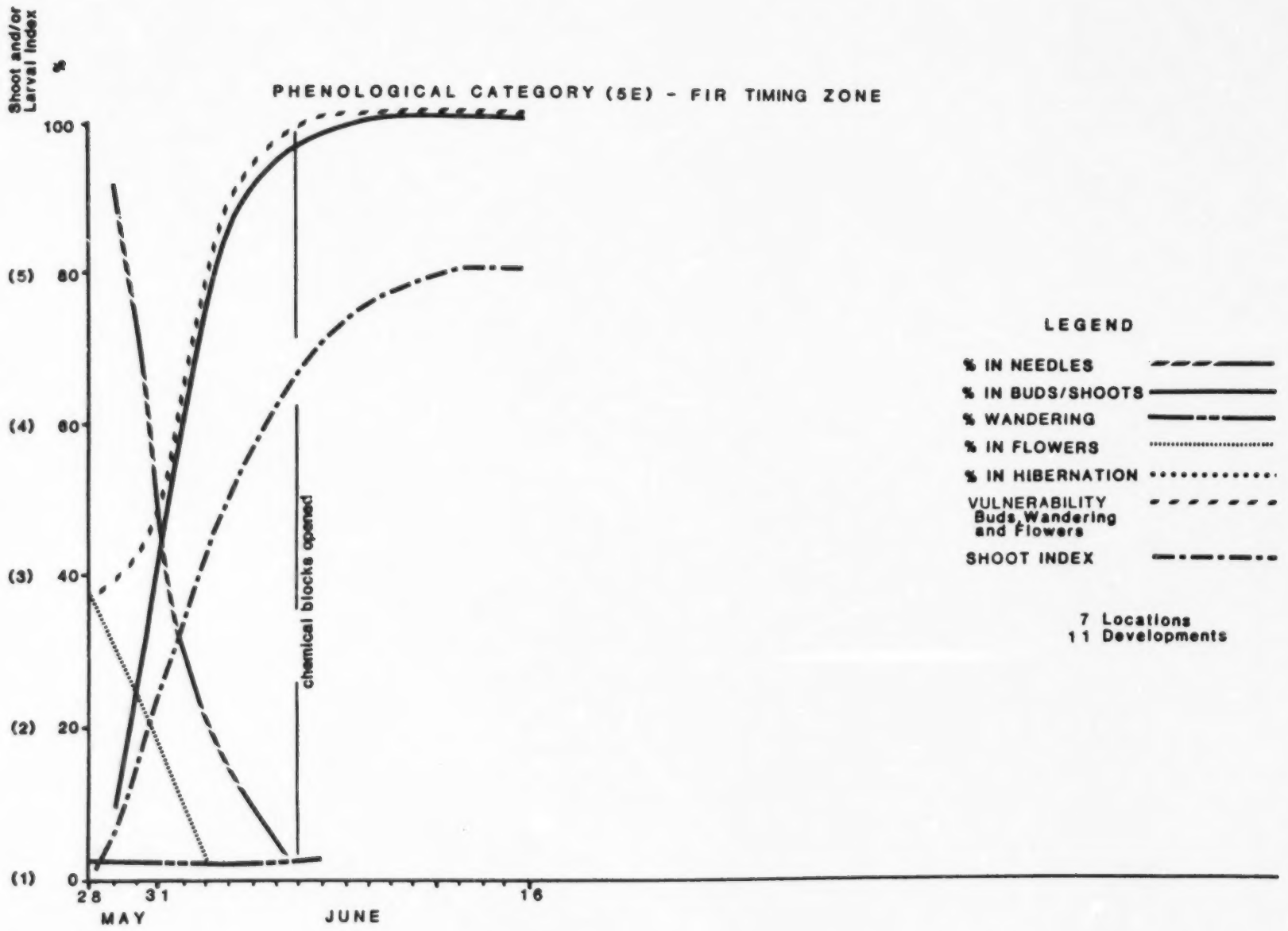

Figure A13. Relationships between larval behaviour and shoot development on balsam fir in phenological category 5E in the Spruce Timed Zone in 1984.

Table A1. Sampling intensity as a function of forest region, treatment, and pre-spray larval density ranges for each host tree species.

		NO. OF BLOCKS SAMPLED																							
		BALSAM FIR							RED/BLACK SPRUCE							WHITE SPRUCE									
		DEFOL.	no. larvae/45cm tip						DEFOL.	no. larvae/45cm tip						DEFOL.	no. larvae/45cm tip								
REGION	TREATMENT	ONLY	0-9	10-19	20-29	30-39	40+	TOT	ONLY	0-9	10-19	20-29	30-39	40+	TOT	ONLY	0-9	10-19	20-29	30-39	40+	TOT			
1	TBM - 2x FEN.	0	1	1	0	0	0	2	0	0	2	0	0	0	2	0	1	1	0	0	0	2			
	TBM - 2x MAT.	7	2	2	0	0	0	11	7	2	2	0	0	0	11	3	2	0	0	1	0	6			
	TBM - 1x MAT.	3	1	0	0	0	0	4	3	1	0	0	0	0	4	4	0	0	0	0	0	4			
	Total	10	4	3	0	0	0	17	10	3	4	0	0	0	17	7	3	1	0	1	0	12			
2	TBM - 2x FEN.	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0			
	TBM - 2x MAT.	8	3	4	0	0	0	15	8	0	6	1	0	0	15	2	0	0	0	0	0	2			
	TBM - 1x MAT.	1	0	0	1	0	0	2	1	0	1	0	0	0	2	0	0	0	0	0	0	0			
	Total	9	3	5	1	0	0	18	9	0	8	1	0	0	18	2	0	0	0	0	0	2			
3	TBM - 2x MAT.	3	0	1	0	0	0	4	3	0	1	0	0	0	4	1	0	0	0	0	0	1			
4	TBM - 2x FEN.	4	1	1	0	0	0	6	5	0	1	1	0	0	7	2	0	0	0	0	0	2			
	TBM - 2x MAT.	1	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0			
	TBM - 1x B.t.	1	1	0	0	0	0	2	1	0	1	0	0	0	2	0	0	0	0	0	0	0			
	Total	6	2	1	0	0	0	9	7	0	2	1	0	0	10	2	0	0	0	0	0	2			
5	TBM - 2x FEN.	0	2	4	0	0	0	6	0	5	1	0	0	0	6	0	1	3	0	0	0	4			
	Total	0	2	4	0	0	0	6	0	5	1	0	0	0	6	0	1	3	0	0	0	4			
TOTAL FOR PROVINCE		28	11	14	1	0	0	54	29	8	16	2	0	0	55	12	4	4	0	1	0	21			

Table A1. Cont'd

		NO. OF BLOCKS SAMPLED																		
		BALSAM FIR							RED/BLACK SPRUCE							WHITE SPRUCE						
REGION	TREATMENT	DEFOL. ONLY	no. larvae/45cm tip 0-9	10-19	20-29	30-39	40+	TOT	DEFOL. ONLY	no. larvae/45cm tip 0-9	10-19	20-29	30-39	40+	TOT	DEFOL. ONLY	no. larvae/45cm tip 0-9	10-19	20-29	30-39	40+	TOT
1	SM-2x FEN.	7	1	4	0	0	0	12	5	2	2	0	0	0	9	4	0	1	1	0	0	6
	SM-2x MAT.	0	0	1	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	1
	SM-1x B.t.	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0
	Total	7	2	5	0	0	0	14	5	4	2	0	0	0	11	4	1	1	1	0	0	7
2	SM-2x FEN.	5	6	4	0	0	0	15	5	2	4	3	1	0	15	1	1	1	0	0	0	3
	SM-2x MAT.	4	1	1	0	0	0	6	5	0	2	0	0	0	7	2	0	0	0	0	0	2
	SM-1x B.t.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	9	7	5	0	0	0	21	10	2	6	3	1	0	22	3	1	1	0	0	0	5
3	SM-2x FEN.	16	1	1	0	0	0	18	18	2	0	0	0	0	20	1	0	0	0	0	0	1
	SM-1x B.t.	0	0	5	0	0	0	5	0	1	1	2	0	1	5	0	0	1	0	0	0	1
	Total	16	1	6	0	0	0	23	18	3	1	2	0	1	25	1	0	1	0	0	0	2
4	SM-2x FEN.	14	2	4	0	0	0	20	14	0	1	2	2	1	20	2	0	0	1	0	0	3
	SM-2x MAT.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SM-1x B.t.	3	10	9	1	0	0	23	3	5	9	3	3	1	24	0	1	1	1	1	0	4
	Total	17	12	13	1	0	0	43	17	5	10	5	5	2	44	2	1	1	2	1	0	7
5	SM-2x FEN.	4	0	0	0	0	0	4	3	0	0	0	0	0	3	3	0	0	0	0	0	3
	Total	4	0	0	0	0	0	4	3	0	0	0	0	0	3	3	0	0	0	0	0	3
	TOTAL FOR PROVINCE	53	22	29	1	0	0	105	53	14	19	10	6	3	105	13	3	4	3	1	0	24

Table A1. Cont'd

		NO. OF BLOCKS SAMPLED																							
		BALSAM FIR							RED/BLACK SPRUCE							WHITE SPRUCE									
REGION	TREATMENT	DEFOL. ONLY	no. larvae/45cm tip						DEFOL. ONLY	no. larvae/45cm tip						DEFOL. ONLY	no. larvae/45cm tip								
			0-9	10-19	20-29	30-39	40+	TOT		0-9	10-19	20-29	30-39	40+	TOT		0-9	10-19	20-29	30-39	40+	TOT			
1	IRVING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
2	IRVING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
3	IRVING	1	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0			
4	IRVING	5	0	0	0	0	0	5	5	0	0	0	0	0	5	0	0	0	0	0	0	0			
5	IRVING	12	0	0	0	0	0	12	12	0	0	0	0	0	12	4	0	0	0	0	0	4			
	TOTAL FOR PROVINCE	18	0	0	0	0	0	18	18	0	0	0	0	0	18	4	0	0	0	0	0	4			

Table A1. Cont'd

		NO. OF BLOCKS SAMPLED																		
		BALSAM FIR							RED/BLACK SPRUCE							WHITE SPRUCE						
REGION	TREATMENT	DEFOL. ONLY	no. larvae/45cm tip 0-9	10-19	20-29	30-39	40+	TOT	DEFOL. ONLY	no. larvae/45cm tip 0-9	10-19	20-29	30-39	40+	TOT	DEFOL. ONLY	no. larvae/45cm tip 0-9	10-19	20-29	30-39	40+	TOT
1	CONTROL	0	4	4	0	0	0	8	0	5	1	2	0	0	8	0	1	0	0	0	0	1
2	CONTROL	0	2	5	3	0	0	10	0	3	6	1	0	0	10	0	0	0	0	0	0	0
3	CONTROL	0	0	2	0	0	0	2	0	0	1	1	0	0	2	0	0	0	0	0	0	0
4	CONTROL	0	5	2	0	0	0	7	0	1	4	2	0	0	7	0	1	1	0	0	0	2
5	CONTROL	0	5	0	0	0	0	5	0	5	0	0	0	0	5	0	5	0	0	0	0	5
	TOTAL FOR PROVINCE	0	16	13	3	0	0	32	0	14	12	6	0	0	32	0	7	1	0	0	0	8

Table A2. Sampling intensity within DNR Administrative Regions by treatment, and pre-spray larval density ranges for each host tree species.

		NUMBER OF PLOTS SAMPLED																							
		BALSAM FIR								RED/BLACK SPRUCE								WHITE SPRUCE							
		LOST	DEFOL.	no. larvae/45cm tip						LOST	DEFOL.	no. larvae/45cm tip						LOST	DEFOL.	no. larvae/45cm tip					
REGION	TREATMENT	PLOTS	ONLY	0-9	10-19	20-29	30-39	40+	TOT	PLOTS	ONLY	0-9	10-19	20-29	30-39	40+	TOT	PLOTS	ONLY	0-9	10-19	20-29	30-39	40+	TOT
1	TBM-2x FEN.	0	0	30	20	3	1	0	54	0	0	9	12	0	0	0	21	0	0	17	11	1	1	0	30
	TBM-2x MAT.	0	94	59	22	4	0	0	179	0	97	51	21	6	1	0	176	0	10	5	2	2	1	1	21
	TBM-1x MAT.	0	126	20	0	0	0	0	146	0	85	4	0	0	0	0	89	0	32	0	0	0	0	0	32
	Totals	0	220	109	42	7	1	0	379	0	182	64	33	6	1	0	286	0	42	22	13	3	2	1	83
2	TBM-2x FEN.	0	0	11	17	0	0	0	28	0	0	13	14	0	0	0	27	0	2	0	0	0	0	0	0
	TBM-2x MAT.	2	156	79	82	21	1	2	343	3	181	58	91	32	4	3	372	0	5	0	0	0	0	0	5
	TBM-1x MAT.	0	28	1	12	11	5	1	58	0	28	2	11	6	1	1	49	0	0	0	0	0	0	0	0
	Totals	2	184	91	111	32	6	3	429	3	209	73	116	38	5	4	448	0	5	0	0	0	0	0	5
3	TBM-2x MAT.	2	29	11	3	0	0	1	46	0	53	6	13	8	2	0	82	0	1	0	0	0	0	0	1
	Totals	2	29	11	3	0	0	1	46	0	53	6	13	8	2	0	82	0	1	0	0	0	0	0	1
4	TBM-2x FEN.	4	34	25	9	1	0	0	73	3	82	15	21	8	5	2	136	0	2	0	0	0	0	0	2
	TBM-2x MAT.	0	20	0	0	0	0	0	20	0	29	0	0	0	0	0	29	0	0	0	0	0	0	0	0
	TBM-1x B.t.	0	18	22	6	1	0	0	47	0	12	8	13	4	2	0	39	0	0	0	0	0	0	0	0
	Totals	4	72	47	15	2	0	0	140	3	123	23	34	12	7	2	204	0	2	0	0	0	0	0	2
5	TBM-2x FEN.	0	0	86	61	12	3	0	162	0	0	62	15	3	0	1	81	0	0	17	16	0	2	0	35
	Totals	0	0	86	61	12	3	0	162	0	0	62	15	3	0	1	81	0	0	16	16	0	2	0	35
	TOTAL FOR PROVINCE	8	505	344	232	53	10	4	1156	6	567	228	211	67	15	7	1101	0	50	39	29	3	4	1	126

Table A2. Cont'd

		NUMBER OF PLOTS SAMPLED																							
		BALSAM FIR								RED/BLACK SPRUCE								WHITE SPRUCE							
				no. larvae/45cm tip								no. larvae/45cm tip								no. larvae/45cm tip					
REGION	TREATMENT	LOST PLOTS	DEFOL. ONLY	0-9	10-19	20-29	30-39	40+	TOT	LOTS PLOTS	DEFOL. ONLY	0-9	10-19	20-29	30-39	40+	TOT	LOST PLOTS	DEFOL. ONLY	0-9	10-19	20-29	30-39	40+	TOT
1	SM-2x FEN.	0	87	21	18	5	2	0	133	0	42	10	12	0	0	0	64	0	34	0	1	2	1	0	38
	SM-2x MAT.	0	0	5	5	0	0	0	10	0	0	4	0	0	0	0	4	0	0	5	0	0	0	0	5
	SM-1x B.t.	0	10	7	3	0	0	0	20	0	4	4	1	0	0	0	9	0	0	0	0	0	0	0	0
	Totals	0	97	33	26	5	2	0	163	0	46	18	13	0	0	0	77	0	34	5	1	2	1	0	43
2	SM-2x FEN.	3	64	59	30	2	0	0	158	0	68	29	46	8	2	9	161	0	2	2	1	0	0	0	5
	SM-2x MAT.	0	21	11	3	0	1	0	36	0	45	7	11	2	0	0	65	0	2	0	0	0	0	0	2
	SM-1x B.t.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Totals	3	85	70	33	2	1	0	194	0	113	35	57	10	2	9	226	0	4	2	1	0	0	0	7
3	SM-2x FEN.	0	103	4	2	0	0	0	109	0	171	15	4	0	0	0	190	0	1	0	0	0	0	0	1
	SM-1x B.t.	0	0	4	30	10	1	0	45	0	0	7	7	13	2	2	31	0	0	0	1	0	0	0	1
	Totals	0	103	8	32	10	1	0	154	0	171	22	11	13	2	2	221	0	1	0	1	0	0	0	2
4	SM-2x FEN.	1	154	19	13	3	1	0	191	0	140	2	7	14	7	13	183	0	8	1	1	0	0	1	11
	SM-2x MAT.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SM-1x B.t.	5	27	84	52	6	3	1	178	9	32	43	62	24	14	6	190	0	0	1	3	4	0	1	9
	Totals	6	181	103	65	9	4	1	369	9	172	45	69	38	21	19	373	0	8	2	4	4	0	2	20
5	SM-2x FEN.	0	55	0	0	0	0	0	55	0	25	0	0	0	0	0	25	0	9	0	0	0	0	0	9
	Totals	0	55	0	0	0	0	0	55	0	25	0	0	0	0	0	25	0	9	0	0	0	0	0	9
	TOTAL FOR PROVINCE	9	521	214	156	26	8	1	935	9	527	120	150	61	25	30	322	0	56	9	7	6	1	2	81

Table A2. Cont'd

		NUMBER OF PLOTS SAMPLED																							
		BALSAM FIR								RED/BLACK SPRUCE								WHITE SPRUCE							
REGION	* TREATMENT	LOST PLOTS	DEFOL. ONLY	no. larvae/45cm tip 0-9	10-19	20-29	30-39	40+	TOT	LOST PLOTS	DEFOL. ONLY	no. larvae/45cm tip 0-9	10-19	20-29	30-39	40+	TOT	LOST PLOTS	DEFOL. ONLY	no. larvae/45cm tip 0-9	10-19	20-29	30-39	40+	TOT
1	IRVING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	IRVING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	IRVING	0	9	0	0	0	0	0	9	0	19	0	0	0	0	0	19	0	0	0	0	0	0	0	0
4	IRVING	0	63	0	0	0	0	0	63	0	62	0	0	0	0	0	62	0	0	0	0	0	0	0	0
5	IRVING	0	241	0	0	0	0	0	241	0	132	0	0	0	0	0	132	0	63	0	0	0	0	0	63
TOTAL FOR PROVINCE		0	313	0	0	0	0	0	313	0	213	0	0	0	0	0	213	0	63	0	0	0	0	0	63

* CONTROL = no treatment applied
IRVING = treatments applied by Forest Patrol Ltd. to J.D. Irving Freehold limits

Table A2. Cont'd

		NUMBER OF PLOTS SAMPLED																					
		BALSAM FIR								RED/BLACK SPRUCE								WHITE SPRUCE							
				no. larvae/45cm twig								no. larvae/45cm twig								no. larvae/45cm twig					
REGION	* TREATMENT	LOST PLOTS	DEFOL. ONLY	0-9	10-19	20-29	30-39	40+	TOT	LOST PLOTS	DEFOL. ONLY	0-9	10-19	20-29	30-39	40+	TOT	LOST PLOTS	DEFOL. ONLY	0-9	10-19	20-29	30-39	40+	TOT
1	CONTROL	3	0	148	42	9	1	0	203	3	0	86	19	9	2	0	119	0	0	22	6	0	0	0	28
2	CONTROL	0	0	26	35	11	5	0	77	0	0	50	91	25	3	1	170	0	0	0	0	0	0	0	0
3	CONTROL	0	0	17	16	3	0	0	36	0	0	17	21	9	4	0	51	0	0	0	0	0	0	0	0
4	CONTROL	2	0	62	25	2	0	1	92	2	0	28	17	11	4	2	64	0	0	2	1	0	0	0	0
5	CONTROL	0	0	14	2	0	0	0	16	0	0	11	0	0	0	0	11	0	0	2	1	0	0	0	3
TOTAL FOR PROVINCE		5	0	267	120	25	6	1	424	5	0	192	148	54	13	3	415	0	0	26	8	0	0	0	34

Table A3. Frequency of blocks (defoliation only) by defoliation class for each combination treatment and host-tree species.

Host	% Def. Classes	Control	Treatment: IBM 2xFen.	IBM 2xMat.	IBM 1xMat.	IBM 1xB.t.	Small Aircraft 2xFen.	Small Aircraft 2xMat.	Small Aircraft 1xB.t.	Irving Treated Areas
balsam	0-20	12	4	14	3	1	36	4	1 3	16
fir	21-40	10	0	5	1	0	6	0	0	2
	41-60	9	0	0	0	0	3	0	0	0
	61-80	1	0	0	0	0	1	0	0	0
	81-100	0	0	0	0	0	0	0	0	0
(no. of plots)		(32)*	(4)	(19)	(4)	(1)	(46)	(4)	(3)	(16)
red-	0-25	27	4	19	3	1	41	5	3	18
black	26-50	5	1	0	1	0	3	0	0	0
spruce	51-75	0	0	0	0	0	1	0	0	0
	76-100	0	0	0	0	0	0	0	0	0
(no. of plots)		(32)*	(5)	(19)	(4)	(1)	(45)	(5)	(3)	(18)
white	0-20	1	3	5	2	0	11	2	4	2
spruce	21-40	7	4	3	0	0	5	1	0	2
	41-60	0	1	0	2	0	0	0	1	0
	61-80	0	0	1	0	0	0	0	0	0
	81-100	0	0	0	0	0	0	0	0	0
(no. of plots)		(8)*	(8)	(9)	(4)	(0)	(16)	(3)	(5)	(4)

* Based on untreated blocks with pre-spray larval counts

Table A4. Summary of block sampling intensity (for blocks sampled pre-spray and defoliation only) within DNR Administrative Regions by treatment and current defoliation levels.

Treatment	DNR Region	Balsam Fir Defoliation 20% Classes 0-20	21-40	41-60	61-80	81-100	Total No. of Blocks	Red-Black Spruce Defoliation 25% Classes 0-25	26-50	51-75	76-100	Total No. of Blocks	White Spruce Defoliation 20% Classes 0-20	21-40	41-60	61-80	81-100	Total No of Blocks
SM - 2x Fen.	1	9	3	0	0	0	12	8	1	0	0	9	3	3	0	0	0	6
	2	10	3	2	0	0	15	13	2	0	0	15	3	0	0	0	0	3
	3	13	2	2	1	0	18	17	2	1	0	20	1	0	0	0	0	1
	4	19	1	0	0	0	20	20	0	0	0	20	3	0	0	0	0	3
	5	2	2	0	0	0	4	2	1	0	0	3	1	2	0	0	0	3
	Total	53	11	4	1	0	69	60	6	1	0	67	11	5	0	0	0	16
SM - 2x Mat.	1	0	1	0	0	0	1	1	0	0	0	1	0	1	0	0	0	1
	2	6	0	0	0	0	6	7	0	0	0	7	2	0	0	0	0	2
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
	Total	6	1	0	0	0	7	8	0	0	0	8	2	1	0	0	0	3
SM - 1x B.t.	1	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	1	3	1	0	0	5	5	0	0	0	5	1	0	0	0	0	1
	4	21	1	1	0	0	23	23	1	0	0	24	3	0	1	0	0	4
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	23	4	2	0	0	29	29	1	0	0	30	4	0	1	0	0	5
Irving	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0
	4	4	1	0	0	0	5	5	0	0	0	5	0	0	0	0	0	0
	5	11	1	0	0	0	12	12	0	0	0	12	2	2	0	0	0	4
	Total	16	2	0	0	0	18	18	0	0	0	18	2	2	0	0	0	4

Table A4. Cont'd

Treatment	DNR Region	Balsam Fir Defoliation 20% Classes 0-20	21-40	41-60	61-80	81-100	Total No. of Blocks	Red-Black Spruce Defoliation 25% Classes 0-25	26-50	51-75	76-100	Total No. of Blocks	White Spruce Defoliation 20% Classes 0-20	21-40	41-60	61-80	81-100	Total No of Blocks
Controls	1	3	2	3	0	0	8	8	0	0	0	9	0	1	0	0	0	1
	2	2	4	3	1	0	10	6	4	0	0	10	0	0	0	0	0	0
	3	0	0	2	0	0	2	2	0	0	0	2	0	0	0	0	0	0
	4	5	2	0	0	0	7	7	0	0	0	7	1	1	0	0	0	2
	5	2	2	1	0	0	5	4	1	0	0	5	0	5	0	0	0	5
	Total	12	10	9	1	0	32	27	5	0	0	32	1	7	0	0	0	8
TBM - 2x Fen.	1	1	1	0	0	0	2	2	0	0	0	2	0	1	1	0	0	2
	2	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	6	0	0	0	0	6	6	1	0	0	7	1	1	0	0	0	2
	5	5	1	0	0	0	6	6	0	0	0	6	2	2	0	0	0	4
	Total	13	2	0	0	0	15	15	1	0	0	16	3	4	1	0	0	8
TBM - 2x Mat.	1	8	3	0	0	0	11	11	0	0	0	11	2	3	0	1	0	6
	2	11	4	0	0	0	15	15	0	0	0	15	2	0	0	0	0	2
	3	3	1	0	0	0	4	4	0	0	0	4	1	0	0	0	0	1
	4	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Total	22	9	0	0	0	31	31	0	0	0	31	5	3	0	1	0	9
TBM - 1x Mat.	1	4	0	0	0	0	4	3	1	0	0	4	2	0	2	0	0	4
	2	0	2	0	0	0	2	2	0	0	0	2	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	4	2	0	0	0	6	5	1	0	0	6	2	0	2	0	0	4
TBM - 1x B.L.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	2	0	0	0	0	2	2	0	0	0	2	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	2	0	0	0	0	2	2	0	0	0	2	0	0	0	0	0	0

Table A5. Cont'd

Treatment	DNR Region	Balsam Fir Defoliation 20% Classes 0-20	21-40	41-60	61-80	81-100	Total No. of Plots	Red-Black Spruce Defoliation 25% Classes 0-25	26-50	51-75	76-100	Total No. of Plots	White Spruce Defoliation 20% Classes 0-20	21-40	41-60	61-80	81-100	Total No of Plots
Controls	1	37	29	19	17	0	102	69	9	2	0	80	3	2	2	0	1	8
	2	22	21	18	12	4	77	122	47	1	0	170	0	0	0	0	0	0
	3	3	14	5	6	8	36	39	11	1	0	51	0	0	0	0	0	0
	4	70	16	1	2	1	90	57	5	0	0	62	1	1	1	0	0	3
	5	77	24	6	7	0	114	32	10	5	0	47	7	13	2	1	0	23
	Total	209	104	49	44	13	419	319	82	9	0	410	11	16	5	1	1	34
TBM - 2x Fen.	1	38	11	5	0	0	54	20	1	0	0	21	3	15	6	6	0	30
	2	23	3	2	0	0	28	21	6	0	0	27	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	57	11	1	0	0	69	117	16	0	0	133	1	1	0	0	0	2
	5	114	38	8	2	0	162	67	13	1	0	81	12	12	9	2	0	35
	Total	232	63	16	2	0	313	225	36	1	0	262	16	28	15	8	0	67
TBM - 2x Mat.	1	146	19	9	4	1	179	162	14	0	0	176	10	7	2	2	0	21
	2	253	57	17	8	6	341	297	64	5	3	369	4	1	0	0	0	5
	3	38	4	2	0	0	44	78	4	0	0	82	1	0	0	0	0	1
	4	10	5	3	2	0	21	25	4	0	0	29	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	447	85	31	14	7	584	562	86	5	3	656	15	8	2	2	0	27
TBM - 1x Mat.	1	119	16	6	4	1	146	78	8	3	0	89	16	5	5	5	1	32
	2	24	25	7	2	0	58	49	0	0	0	49	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	143	41	13	6	1	204	127	8	3	0	138	16	5	5	5	1	32
TBM - 1x B.t.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	41	6	0	0	0	47	38	1	0	0	39	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	41	6	0	0	0	47	38	1	0	0	39	0	0	0	0	0	0

Table A4. Cont'd

Treatment	DNR Region	Balsam Fir Defoliation 20% Classes 0-20	21-40	41-60	61-80	81-100	Total No. of Blocks	Red-Black Spruce Defoliation 25% Classes 0-25	26-50	51-75	76-100	Total No. of Blocks	White Spruce Defoliation 20% Classes 0-20	21-40	41-60	61-80	81-100	Total No of Blocks
Controls	1	3	2	3	0	0	8	8	0	0	0	8	0	1	0	0	0	1
	2	2	4	3	1	0	10	6	4	0	0	10	0	0	0	0	0	0
	3	0	0	2	0	0	2	2	0	0	0	2	0	0	0	0	0	0
	4	5	2	0	0	0	7	7	0	0	0	7	1	1	0	0	0	2
	5	2	2	1	0	0	5	4	1	0	0	5	0	5	0	0	0	5
	Total	12	10	9	1	0	32	27	5	0	0	32	1	7	0	0	0	8
TBM - 2x Fen.	1	1	1	0	0	0	2	2	0	0	0	2	0	1	1	0	0	2
	2	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	6	0	0	0	0	6	6	1	0	0	7	1	1	0	0	0	2
	5	5	1	0	0	0	6	6	0	0	0	6	2	2	0	0	0	4
	Total	13	2	0	0	0	15	15	1	0	0	16	3	4	1	0	0	8
TBM - 2x Mat.	1	8	3	0	0	0	11	11	0	0	0	11	2	3	0	1	0	6
	2	11	4	0	0	0	15	15	0	0	0	15	2	0	0	0	0	2
	3	3	1	0	0	0	4	4	0	0	0	4	1	0	0	0	0	1
	4	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	22	9	0	0	0	31	31	0	0	0	31	5	3	0	1	0	9
TBM - 1x Mat.	1	4	0	0	0	0	4	3	1	0	0	4	2	0	2	0	0	4
	2	0	2	0	0	0	2	2	0	0	0	2	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	4	2	0	0	0	6	5	1	0	0	6	2	0	2	0	0	4
TBM - 1x B.t.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	2	0	0	0	0	2	2	0	0	0	2	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	2	0	0	0	0	2	2	0	0	0	2	0	0	0	0	0	0

Table A5. Summary of plot sampling intensity (for plots sampled pre-spray and defoliation only) within DNR Administrative Regions by treatment and current defoliation levels.

		NO. OF BLOCKS SAMPLED																		
		BALSAM FIR							RED/BLACK SPRUCE							WHITE SPRUCE						
REGION	TREATMENT	DEFOL. ONLY	no. larvae/45cm tip 0-9	10-19	20-29	30-39	40+	TOT	DEFOL. ONLY	no. larvae/45cm tip 0-9	10-19	20-29	30-39	40+	TOT	DEFOL. ONLY	no. larvae/45cm tip 0-9	10-19	20-29	30-39	40+	TOT
1	TBM - 2x FEN.	0	1	1	0	0	0	2	0	0	2	0	0	0	2	0	1	1	0	0	0	2
	TBM - 2x MAT.	7	2	2	0	0	0	11	7	2	2	0	0	0	11	3	2	0	0	1	0	6
	TBM - 1x MAT.	3	1	0	0	0	0	4	3	1	0	0	0	0	4	4	0	0	0	0	0	4
	Total	10	4	3	0	0	0	17	10	3	4	0	0	0	17	7	3	1	0	1	0	12
2	TBM - 2x FEN.	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0
	TBM - 2x MAT.	8	3	4	0	0	0	15	8	0	6	1	0	0	15	2	0	0	0	0	0	2
	TBM - 1x MAT.	1	0	0	1	0	0	2	1	0	1	0	0	0	2	0	0	0	0	0	0	0
	Total	9	3	5	1	0	0	18	9	0	8	1	0	0	18	2	0	0	0	0	0	2
3	TBM - 2x MAT.	3	0	1	0	0	0	4	3	0	1	0	0	0	4	1	0	0	0	0	0	1
4	TBM - 2x FEN.	4	1	1	0	0	0	6	5	0	1	1	0	0	7	2	0	0	0	0	0	2
	TBM - 2x MAT.	1	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0
	TBM - 1x B.t.	1	1	0	0	0	0	2	1	0	1	0	0	0	2	0	0	0	0	0	0	0
	Total	6	2	1	0	0	0	9	7	0	2	1	0	0	10	2	0	0	0	0	0	2
5	TBM - 2x FEN.	0	2	4	0	0	0	6	0	5	1	0	0	0	6	0	1	3	0	0	0	4
	Total	0	2	4	0	0	0	6	0	5	1	0	0	0	6	0	1	3	0	0	0	4
TOTAL FOR PROVINCE		28	11	14	1	0	0	54	29	8	16	2	0	0	55	12	4	4	0	1	0	21

Table A5. Cont'd

Treatment	DNR Region	Balsam Fir Defoliation 20% Classes 0-20	21-40	41-60	61-80	81-100	Total No. of Plots	Red-Black Spruce Defoliation 25% Classes 0-25	26-50	51-75	76-100	Total No. of Plots	White Spruce Defoliation 20% Classes 0-20	21-40	41-60	61-80	81-100	Total No of Plots
Controls	1	37	29	19	17	0	102	69	9	2	0	80	3	2	2	0	1	8
	2	22	21	18	12	4	77	122	47	1	0	170	0	0	0	0	0	0
	3	3	14	5	6	8	36	39	11	1	0	51	0	0	0	0	0	0
	4	70	16	1	2	1	90	57	5	0	0	62	1	1	1	0	0	3
	5	77	24	6	7	0	114	32	10	5	0	47	7	13	2	1	0	23
	Total	209	104	49	44	13	419	319	82	9	0	410	11	16	5	1	1	34
TBM - 2x Fen.	1	38	11	5	0	0	54	20	1	0	0	21	3	15	6	6	0	30
	2	23	3	2	0	0	28	21	6	0	0	27	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	57	11	1	0	0	69	117	16	0	0	133	1	1	0	0	0	2
	5	114	38	8	2	0	162	67	13	1	0	81	12	12	9	2	0	35
	Total	232	63	16	2	0	313	225	36	1	0	262	16	28	15	8	0	67
TBM - 2x Mat.	1	146	19	9	4	1	179	162	14	0	0	176	10	7	2	2	0	21
	2	253	57	17	8	6	341	297	64	5	3	369	4	1	0	0	0	5
	3	38	4	2	0	0	44	78	4	0	0	82	1	0	0	0	0	1
	4	10	5	3	2	0	21	25	4	0	0	29	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	447	85	31	14	7	594	562	86	5	3	656	15	8	2	2	0	27
TBM - 1x Mat.	1	119	16	6	4	1	146	78	8	3	0	89	16	5	5	5	1	32
	2	24	25	7	2	0	58	49	0	0	0	49	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	143	41	13	6	1	204	127	8	3	0	138	16	5	5	5	1	32
TBM - 1x B.t.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	41	6	0	0	0	47	38	1	0	0	39	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	41	6	0	0	0	47	38	1	0	0	39	0	0	0	0	0	0